Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR.

VOL. X. NEW YORK, NOVEMBER, 1905. No. 9.

"Compressed Air,"

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATIONS OF COMPRESSED AIR.

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Pneumatic Tools in the Monument Shop.

While it is generally recognized that compressed air is of practical service to the stone cutter, it is interesting to hear it declared indispensable to the field by one who is in a position to know. At the annual convention of the Wisconsin Granite and Marble Dealers' Association, held at Oshkosh, Wisconsin, last August, Mr. Fred K. Irvine, of *Rock Products,* had something to say regarding the pneumatic tool in the retail monument shop.

"Only a few years ago," declared Mr. Irvine, "there was a doubt in the minds of many monument men as to whether tools propelled by compressed air would ever be a pronounced success in the retail monument establishment where a small number of workmen were found adequate to take care of the business. Some of the concerns who were the first to put in compressors complained that it did not pay them. They froze out. They had leaks that could not be stopped, and the tools were claimed to be of imperfect construction; and with one excuse and another a great deal of dissatisfaction was expressed, and some of these concerns charged up considerable loss against their compressed air experiments, finally throwing out the machinery, and up to this day they are doing their work by hand, as it has been done from the time the Egyptians first carved the inscriptions upon their obelisks, which antedate all history.

"This may be termed the experimental stage of compressed air in the monumental establishment, for it was experiment, pure and simple, and the result of many experiments has been the steady and rapid improvement, both of the compressor plant and of the tool which does the work, so that to-day there are several absolutely perfect systems for compressing air to the necessary tension, and tools are to be had as perfect as human ingenuity, skill and experience can produce, so that the up-to-date monumental establishment finds compressed air and pneumatic tools practically as indispensable as the stone itself. When for any reason it is found necessary to close down the plant temporarily for repairs, or for any other reason, the workmen who have become familiar with the operation of pneumatic tools, in every instance, would prefer to lay off and lose the time than to return to the old method of mallet and chisel. In fact, the workmen soon learn to think that it is impossible to proceed without the air plant being in good working order."

The rest of his speech, which is reprinted in another column, dealt with the details of the work and the care and use of the tools.

With the development of the pneumatic hammer it was soon apparent that these tools might be used with great success for cutting stone. The air hammer, designed to chip metal, was not particularly adapted to the cutting of stone. As a

result, we have seen the development of a new line of pneumatic tools, intended to meet the particular requirements of this field. These tools are not confined to hammers, but include others of a character applicable only to the stone trade. It did not require much time to convince the monument dealers of the value of these devices, and the result, as pointed out by Mr. Irvine, was in the general adoption of compressed air machinery in the marble, granite and other stone yards throughout the country.

This field has developed very quietly, but its importance is beyond question. It will require inventions of a very radical nature to dislodge the hold compressed air has in the monument business.

A Central Compressed Air Power Plant for Heavy Railroad Construction.

THE "LOW-GRADE FREIGHT LINE" OF THE P. R. R. NEAR SAFE HARBOR, PA.

Some of the heaviest work in the history of railway construction is now nearing completion on the "low-grade freight line" of the Pennsylvania Railroad, paralleling the Susquehanna River in its course through the southern part of Pennsylvania. The plans now being carried out involve a double-track line at a height above the river which will avoid all difficulty from high water; and its object is to relieve the congested freight traffic on the main line, as well as to reduce the grades for the heavy freight hauls which mark this section of the road. Probably the most difficult conditions were met on a section about 9 miles in length, beginning on the north near Columbia, Pennsylvania, and reaching to Modic Fords on the south. Along this stretch the hills jut into the river with abrupt headlands of solid rock several hundred feet high, and in many cases almost perpendicular. The work here has consisted of a continuous cut in solid rock; and the almost vertical hillside has made necessary the removal of vast quantities of rock with tremendous charges of powder, before the necessary width could be secured at grade. This section is especially interesting and noteworthy, in that, practically all the excavating machinery over the entire nine-mile line has been driven by air power supplied from a central air plant, located about midway of the work at the mouth of Conestoga Creek, near Safe Harbor.

This is the largest piece of railway work ever carried on with air power from a central station, and it marks a distinct advance, if not a revolutionary change, in railway construction methods and pneumatic power practice.

The contractor for this work is H. S. Kerbaugh, Inc., of Philadelphia; and the air power system—the largest ever used on contract work—was installed under the direction of the Philadelphia office of the Ingersoll-Sergeant Drill Company, of New York. In the description of the system which follows it is to be remembered that the plant is essentially temporary in character, and was installed with a view to later sub-division among minor contracts. This fact will explain many seeming irregularities in design.

Safe Harbor was selected as the location for the plant, not only because of its central location in relation to the work, but also because there was available at that place a large building which could be used for power purposes. This building, 160 by 260 feet in size, is of brick and mill construction; it was originally a match factory, but was later used as a rolling mill. It has been made the headquarters of the mechanical department of the contract, and in it are installed the boiler and compressor plant, the machine, forge and carpenter shops, and the general storage warehouse. Near it are grouped the local executive offices of the company.

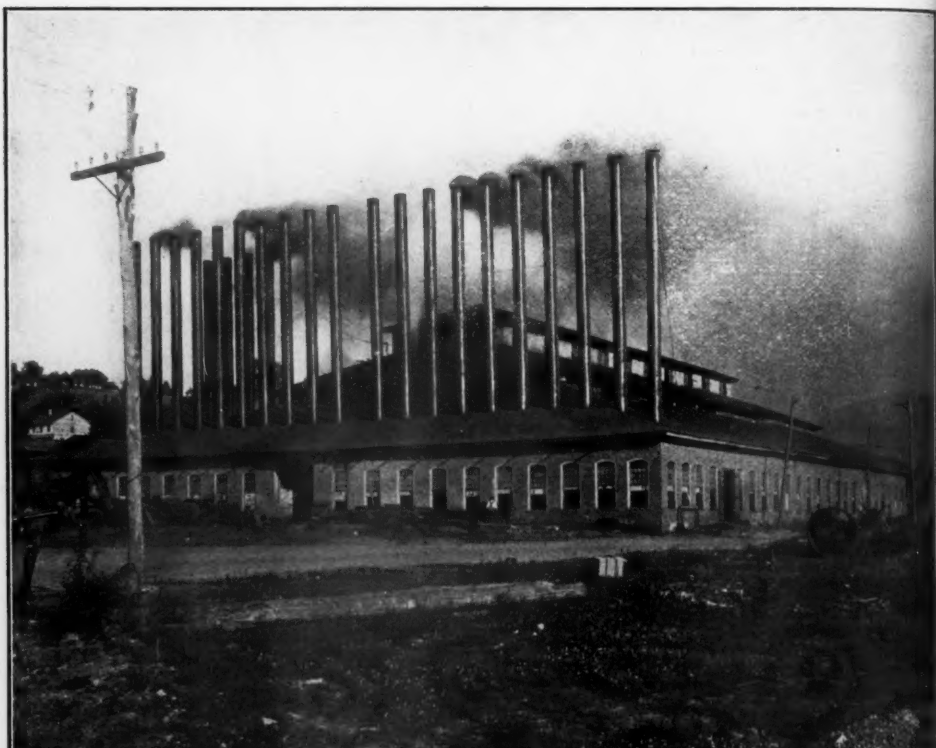
The boilers are arranged along the northern side of the building, 20 in one row, with a battery of 4 more facing them at one end. They are of horizontal tubular locomotive type, installed without settings, and rated at 100 boiler horsepower, thus giving a total steam plant capacity of 2,400 boiler horsepower. Each boiler has its own stack, about 80 feet in height, and the peculiar appearance of the power house resulting is seen in the accompanying illustration of the exterior. Coal is stored in an outside bin of about 5,000 tons capacity, and delivered to the fire floor by hand cars running on a track in front of the boilers.

DRILL RIGS USED IN SINKING BLAST HOLES.

The plant is hand-fired, about 40 tons of slack coal being burned per day.

Water is delivered to a cold well in the middle of the power house from a dam two miles distant, under a head of about 22 feet. This cold well is the source of cooling water for the air compressors, as well as for boiler feed water. Three 10x7x10-inch duplex steam pumps are installed, one handling the boiler feed, one the circulating water for compressors, and the third being a reserve unit for either of the others, as well as a fire pump, in emergency. Water pipe connections are such that these three pumps are interchangeable in their functions. Feed water, after passing through a 2,000 horsepower vertical exhaust steam feed water heater, is delivered to the boilers through a feed main laid in the rear of the battery, with independent branches to each unit. The steam pressure carried on the boilers is 100 pounds.

There are two steam headers in the plant. One is the boiler header, paralleling the boiler fronts. This is a taper line, with the maximum diameter of 16 inches in the middle and reducing to 6 inches at the ends; the boiler risers are 6-inch pipe. The second is the main steam headers, paralleling the line of compressors. It, too, is a taper line, with a maximum of 16 inches in the middle and a minimum of 6 inches at the ends. The steam pipe to each compressor rises from the top of the header and is protected by



EXTERIOR VIEW OF THE COMPRESSED AIR STATION ON THE KERBAUGH CONTRACT.

an angle valve. Extra heavy flanged fittings are used throughout. The headers are supported by wrought columns rising from the floor and terminating in a saddle at the top. A 16-inch main unites boiler header and steam header, connected in at the middle of each.

The air compressors constitute the major part of the load on the boilers. But steam is also supplied to the pumps, the machine shop engine, an electric lighting unit, and, in cold weather, to a fan engine for the shop heating system. The grouping of all these mechanical departments under one roof simplifies the problems of local power distribution.

RECEIVERS IN COMPRESSED AIR POWER PLANT.

The exhaust header parallels the steam header, and increases from 7-inch section at the ends to 20-inch section in the middle, from which point a 20-inch exhaust main leads to the heater. A spiral riveted steel pipe rises from the heater to the exhaust outside. Each compressor exhaust pipe is fitted with a valve at the exhaust header.

The battery of air compressors is made up of eight units arranged with their shafts in a line at right angles to the line of boiler fronts. Each unit is an Ingersoll-Sergeant Class "A" straight-line single-stage air compressor, with a steam cylinder 24 inches in diameter, air cylinder

24¼ inches, and a stroke of 30 inches. The normal speed is 80 R.P.M., at which each machine has a piston displacement of 1,223 cubic feet per minute, giving a total air capacity of 9,784 cubic feet per minute delivered at 95 pounds pressure. These compressors are controlled by the Sergeant "Air-Ball" speed and pressure regulator and fitted the Sergeant Piston Inlet Valve; discharge valves are of standard direct-lift type and the air cylinders are completely water-jacketed on heads and barrel. The units are mounted on independent masonry foundations, 12 feet apart, centre to centre. Compressor discharge pipes lead to a 6-inch air header, each being protected by valves so that any machine may be cut out. There are four vertical air receivers, 60 inches in diameter and 14 feet high, arranged in a row in the rear of the compressors. Their discharge pipes connect with a 12-inch air main leading outward to the line. Proper provision is made for drainage of entrained moisture.

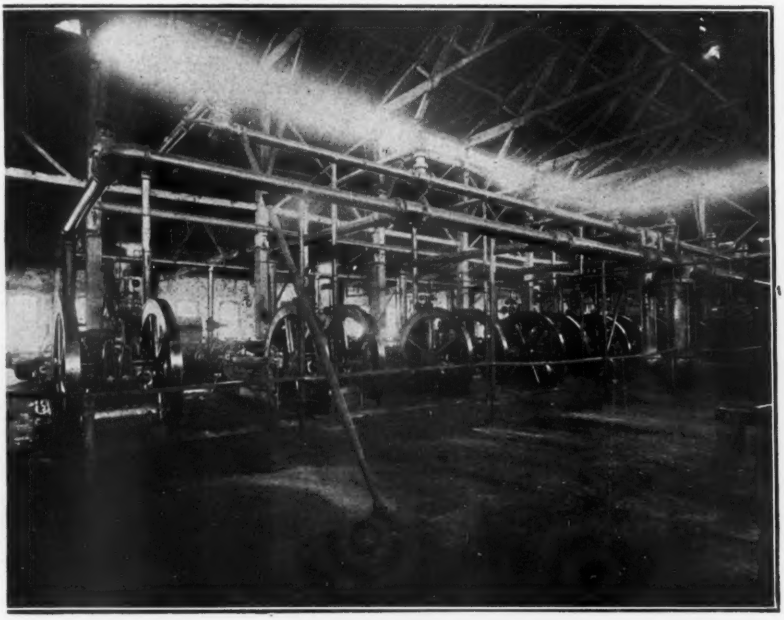
Outside the power house the air line branches; an 8-inch main laid on the eastern side of Conestoga Creek leads a distance of 3,250 feet to the scene of work below. This main supplies the eastern half of the contract. The second branch of 12-inch pipe crosses the creek on a cable suspension, thence runs over the hills on the west side to the railway cut. This latter line supplying the western section is 3,650 feet long. The pipe lines reduce in size as greater distances are reached, until at the extremities of the section a 3-inch main supplies the machines. The pipe is laid on the surface, following the contour of the country. Screwed joints are everywhere used, except that every 500 feet a flange joint is introduced to simplify installation. Every four hundred feet along the line of work a 3-inch branch tee is inserted in the main pipe, from which a 3-inch branch main is carried down the face of the hill to the work below. Expansion and contraction are provided for by swing joints in the pipe line, made up of four elbows, two nipples and a short length of pipe. These are placed wherever the pipe turns a corner, and on straight runs where it is deemed advis-

BOILERS IN THE PLANT OF H. S. KERBAUGH, INC., NEAR SAFE HARBOR, PA.

able. Provision is made at every low place on the line for the removal of water through drain cocks. In all there are about 40,000 feet of main pipe line, with countless branches and sub-branches. The largest direct transmission is 28,650 feet, or 5.4 miles. This great length provides an enormous air storage capacity in the system and obviates all minor fluctuations of pressure due to varying load. There is no measurable drop in pressure along the main line; but the ill-advised use of pipe too small in some branches has in places caused a very serious lowering of pressure on the machines.

required no handling. Loose rock remaining was loaded in cars by chain shovels or hand and run back over a light railway to suitable dumping places. But "fills" are remarkably infrequent.

A novelty in this work has been the use of thirty-four heavy well-drilling machines for the deep vertical holes. These were of the ordinary steam-driven type, with engine, boiler and driller mounted on a wheeled truck. But compressed air was the motive power. Two sizes were used, designated as 26 and 30-foot machines. In practice the driller was properly located and a branch pipe from the air main connected by a length of hose to the boiler, which thus served as a secondary receiver. No changes were necessitated in the machine itself by the use of air power. The hole drilled by this arrangement was 5½ inches in diameter all the way down, and varied in depth up to 135 feet. It was a serious matter, in the majority of places, to get these well drillers down to the work, owing to the precipitous character of the country. But in every case the engineers were successful. The illustrations give some idea of the difficulties encountered.



AIR COMPRESSORS IN THE PLANT OF H. S. KERBAUGH, INC., NEAR SAFE HARBOR, PA.

The method of excavation has been that of drilling a number of very deep vertical holes along the inside of the desired cut, and a series of "snake holes" of a suitable depth on a level with the bottom of the vertical holes. These holes were "sprung" by a charge of dynamite, then loaded with blasting powder; and the entire series discharged at once by an electric current from the central plant. Enormous charges were thus used and great quantities of rock dislodged. In many instances the major part of the mass was thrown into the river and

The horizontal or "snake holes" were drilled by standard rock drills, about 250 of these machines having been used on the work. All of them were of the "Auxiliary Valve" type, built by the Ingersoll-Sergeant Drill Company. Owing to the depth of the holes required, these drills were of the heaviest type, with cylinders 3½ inches in diameter. The tripod mounting is used exclusively. The holes drilled varied in depth up to a maximum of 35 feet. The deepest holes were 4½ inches in diameter at the top and diminished to 1⅝ inches at the bottom. It will be readily appreciated that only the heaviest and most powerful drills could work effectively with such long, heavy steels as this work demanded. The rock has varied in quality, but the average has been of a hardness rather above the ordinary. The service has not been easy on the machines. The average work of each drill has been from 40 to 60 feet of hole per day, including the necessary delays due to changing steels and moving. This rate is reported by the contractors to be double that secured where steam was used, on some earlier stages of the work. In this connection it is interesting to note that at one time it was attempted to use steam, supplied from boilers located on the top of the hill and piped to the drills below. But it was found that condensation was so great as to give practically no pressure on the drill, and the scheme was abandoned. Air power was found to be the only solution of the problem.

There have been 16 blacksmith shops scattered along the line of work in which the forges were blown by a small air blast from the main line. Air pressure has been used all along for clearing out the deep holes. There are three 6x4x6 inch duplex pumps on the line, also air-driven from the main plant, raising water from the river to tanks on the bluff above. There have also been on the work at different times ten 6x8-inch duplex hoisting engines, which were driven by air from the common supply. But as the work progressed and drills were added, it was found that these machines required all the air that the compressor plant could furnish; and so individual boilers were installed at each hoist. These latter are now used on the bridge work at the mouth of Conestoga Creek, where a steel bridge is being erected which will have a height at the rails of 140 feet above the normal river level.

Along with the heavy rock drills used for the deepest holes, a few small machines have been used on the lightest work. These were "Little Jap" hammer drills built by the Ingersoll-Sergeant Drill Company—light hand machines similar to the ordinary pneumatic tool. Their use in this work is interesting. Previous to their introduction, it had been the custom in "mud capping" to explode a case of dynamite on the surface of the rock. Later a hole 6 inches deep was drilled with a "Little Jap" and charged with a single stick of dynamite. This was found to do the same amount of shattering that a full case did before, with a great saving of explosive.

Steam shovels were used extensively in removing the rock broken by the blast. They were supplied with steam from their own boilers. But in one instance at least a shovel was connected up to the air line and air power was applied both in removing the rock and in moving the shovel itself. Air power would probably have been applied in the shovels more extensively had it not been found that the drills required practically the entire output of the compressor plant.

A tabulation of the data on the air power at this plant may be convenient at this point, as a resume of the description.

Total free air capacity. 9,784 cu. ft. per min.
Total boiler H. P. . . . . . 2,400.
Air pressure . . . . 95 pounds.
Total load 250 3½-inch drills (150 at work on the average).
3 "Little Jap" hammer drills.
34 Well drillers.
3 6x4x6-inch duplex pumps.
16 Blacksmith forges.
1 Steam shovel.
10 6x8-inch duplex hoists (later run by steam) cleaning drill holes.

It was shown beyond question that steam could not be used for the drills on this contract. This alone would determine the choice of power under like conditions, and in the present case compressed air was adopted very largely on this account. But there are other advantages which, in combination, have resulted not only in a point of great effectiveness, but of high efficiency as well.

The greatest difference between steam and air driven plants for this work lies in the matter of operating cost, including under this head fuel, maintenance and labor charges. Running by steam, a fair average would be a 75 horsepower boiler

for every ten drills, assuming that ten drills could be so located as to draw steam from one boiler. There would thus have been required at least twenty-five 75 horsepower boilers for drills alone; in all probability there would have been more. Each pump would have required its own boiler. The thirty-four well drillers, steam driven, would have called for that many more boilers. With the present equipment there would thus have been required at least sixty-two separate and scattered boilers. To each of these coal and water would have had to be delivered. The drill boilers would have had to be removed from time to time as the work progressed. The small boilers of uneconomical type and wholly unprotected would have had an excessive fuel consumption. Moreover, they would have been exposed to a heavy depreciation, calling for heavy and repeated repairs. The distribution of coal and water to the scattered boilers would have kept a large labor force busy and increased the cost of fuel and water. At each drill and pump boiler an attendant would have been required.

All in all, it is seen that an outfit of steam plants with a work capacity equivalent to that of the present air plant would have multiplied fuel, water and maintained charges many times over that of the present plant, besides largely increasing the labor force.

On the other hand, the centralized air plant, with its single large boiler equipment and compact compressor outfit, reduces fuel attendance and labor charges to the limit. Boilers of more modern type, compressors of higher steam economy, and more correct station design would have given much higher plant efficiency. But the fact that the system was only temporary forbade elaborate design and the multiplication of small units permits their transfer as individuals to other points on subsequent contracts. Even as it stands, this plant is a remarkable instance of high-grade engineering applied to temporary demands.

The use of air power, furthermore, is equivalent to an increase in the length of the working day. For if steam had been used, time would have been lost each day in waiting for steam to be raised. Frozen pipes would have had to be thawed in winter, involving further delay. During all these little waits, men would have been idle. Under the present system, power is everywhere instantly available, and every minute of the working day is effective; every man does his full quota of work—in so far as that is dependent upon power supply.

LUCIUS I. WIGHTMAN, E. E.

A Phase of the Coal-Mining Problem in the Illinois Coal District.

Mining conditions in Illinois have so changed since the passage of the Shot-firer's bill a short time ago, that the coal operator is anything but sure of his ground; for not only the old schedule of wages, but even the old system of mining the coal has been so demoralized that all is chaos. I want to make a few suggestions which I trust will prove of not a little interest, as they mean an absolute remedy against the expense of shot-firing, the main cause of the trouble now brewing.

My remedy is nothing more nor less than a modern compressed air mining plant; the installation of which I feel confident will effect these four material benefits to a mine:

First—By undercutting the coal with a wedge-shape cut (accomplished only with the air puncher), any coal in Illinois can be easily brought down with from one to two pounds of powder. This does away with the shot-firers, and costs incidental to them. As to just what those costs are, it is hard to say; at least two cents a ton will be required from the operator to pay his half, including shot-firers, engineer, fireman, fuel, oil and the added depreciation on his boiler, hoisting-engine, cables and cages; all of which must run half an extra shift every day.

As an example take an average 900-ton mine, with a plant of the above machinery costing $7,000. Figured on the basis of one shift a day it would ordinarily have a life of fifteen years, or a depreciation of 7 per cent. or $490 a year. By working one-half extra shift its life will be decreased to ten years and the depreciation increased to 10 per cent., amounting to an extra $210 a year or 84 cents for each working day, to be added on your cost sheet from shot-firing.

Summed up, the costs will be as follows:

One-half cost of 6 shot-firers at $4.	$12.00
One engineer one-half shift.......	1.35
One fireman one-half shift........	1.21
Two tons coal at 75 cents..........	1.50
Oil	.35
Repairs	.45
Added depreciation	.84
Total	$17.70

At $17.70 a day one would expend in a year of 250 days the sum of $4,425 for fixed charges alone; almost enough to buy a mining plant. Let's see, that would make a 100 per cent. investment.

Now come the charges which none can foresee: extra costs due to shots not going off, leaving places that can not be worked next day, and in small mines with but few working places at best this is serious. You cannot blame the shot-firer for not caring to camp on the premises and experimenting till he gets the shots all off. His duty ends with his honest attempt to make the shot go, if it hangs, he can't and won't waste the night on it.

This results in a diminished output; for every place not shot down when the shot-firers are in the mine mean just so many unworkable places the next day and so many idle and angry miners. One mine I bear in mind has had its output reduced from 1,400 to 800 tons a day, and absolutely unable to bring it up except by installing mining machines, which they are now figuring on. At this mine there is anything but pleasant relations between miner and firer. Another bad feature is that after the shot-firers leave, the mine is so full of smoke it cannot be used for several hours, and this added to the time taken up in shooting, means a pretty good percentage of the 24 hours, during which the mine is entirely out of the owner's hands. No time for improvements of any kind. Then accidents are bound to be numerous and mighty expensive. (One death in the first twenty days is certainly booming matters.) The miner has naturally much more love for his own life than that of his fellows, and if, through carelessness or animosity, he used an excessive charge, got his hole in the wrong direction, or did any of the other things which are easier to do wrong than right, why, good gracious, the loss of property or life might be fearful.

Summed up—The cost will not be less than two cents and may be ten for every ton. In truth the earmarks for ten look strong.

Second—There will be a saving of two or three cents a ton from the seven cents differential now in force. Four cents a ton is a very high fixed charge on a plant, even taking wages, fuel, oil, depreciation at 7½ per cent., interest at 4 per cent., insurance at 2 per cent. and everything into consideration. The chances are that next year this differential will be increased to at least ten cents a ton, meaning three cents more profit for the man with the machine. The danger of its being decreased is very small, for by the Interstate Agreement Illinois now has far the lowest of any of the States, in Ohio and Pennsylvania the differential going up to 15 cents a ton.

Third—The lump coal will be increased at least 25 per cent., meaning an average extra profit of 6 cents on every ton (with lump selling at $1.10 and screenings at 60 cents) over the present shooting off the solid system giving an average of 55 per cent. screenings. Take a 100-ton plant on the solid basis. They get 45 tons lump at $1.10 and 55 tons screenings at 60 cents or $82.50 for the 100 tons. Now by using a machine they would get 56¼ tons lump at $1.10 and 43¾ tons slack at 60 cents or $88.12 for all. A saving of $5.62 or nearly 6 cents a ton. Don't take my word on this, ask your machine neighbor, he knows.

Fourth—The production per employee will be increased 33⅓ per cent., meaning a much smaller force for a given output. Always a big benefit in case of the thousand and one contingencies, any of which are apt to arise on short notice at a coal mine.

Now that I have stated the benefits you can look for by the installation of machinery, I will try and give an idea of what a plant costs and comprises.

Mining plants are figured on the basis of how many mining machines are supplied for the required output. For instance, you have an eight-foot vein of coal in which a machine can cut 100 tons per day. You desire an output of 1,000 tons, or what is called a ten-machine plant. Ordinarily in Illinois a machine will cut from 60 to 120 tons a day, depending on the thickness (running from 5 to 10 feet) and the character of the coal.

As to cost—the following are close

enough to give a clear idea as to what an installation will amount to:

A three machine plant will cost.	$3,500.00
A six machine plant will cost..	5,500.00
A ten machine plant will cost....	8,000.00
A fifteen machine plant will cost.	12,000.00
A twenty machine plant will cost.	14,000.00

This price includes a horizontal return tubular boiler for the small plants, or a battery of two boilers with the large, a straight-line air compressor (capable of running the given number of machines) two air receivers (one large for storage, and one small to trap the moisture from the air in the mine), the required number of mining machines, pump for water jacket circulation and a complete pipe system, including main branch and room pipe with all fittings. All freight, labor and foundation material is likewise included.

Now figure what can be saved a ton by machinery (ten to twelve cents) multiply this by the output and figure how many days it will take to pay for a plant.

M. L. HYDE,
St. Louis, Mo.

Valve Gear for Air Compressors.

Air compressors from a valve gear standpoint are divided into two classes, those having automatic valves and those in which the valves are positively controlled. Many compressors combine the two classes. In comparing the merits of automatic and positive valve compressors it is necessary to consider the conditions under which they operate before a true estimate of their relative advantages can be formed. Dealing first with the suction valves, those of the automatic class have the advantage that no extraneous gear such as eccentric rods and levers are necessary; but, on the other hand, the fluid resistance of an automatic compressor exceeds that of the positive type.

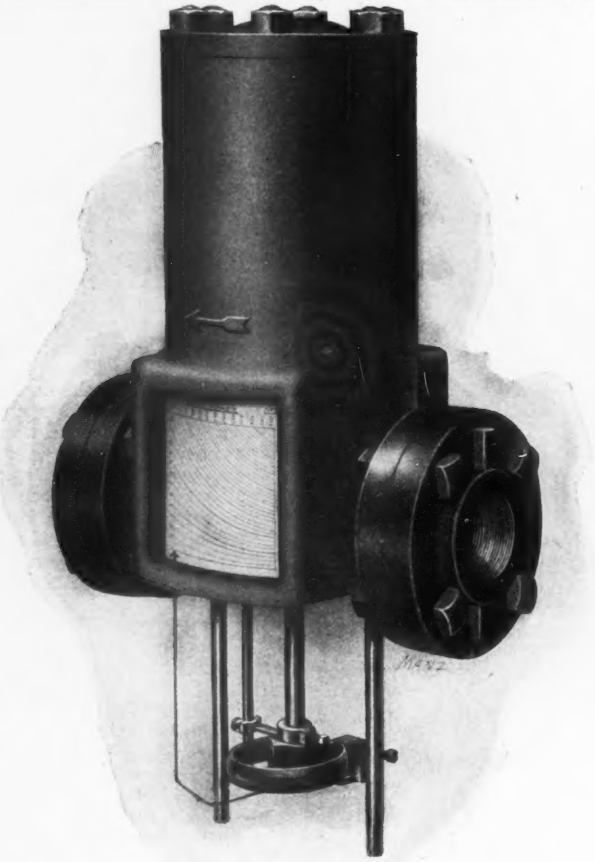
In compound compressors the low pressure or intake-cylinder may with advantage be fitted with mechanically-moved valves for both suction and delivery, because in this cylinder a constant delivery pressure to the intercooler is obtained in spite of fluctuations in pressure in the delivery main; and when the valves have once been set they require no further adjustment in the timing of their functions. It has been previously stated that the fluid resistance of the suction stroke has a considerable effect in reducing the capacity of a machine, but in the second cylinder it has little or no effect on the output.

If in entering the cylinder the air passes in thin streams through hot passages or ports, or past hot valves or seats, it will become rarefied, and thereby reduce the capacity of the compressor. The valve arrangements should therefore be designed to avoid this effect as much as possible. The passages leading to the suction port should be kept away from the heat of the cylinder, and should be as large and as direct as convenient. Automatic delivery valves of air compressors are by far the most common type, and when well designed are quite satisfactory, and it is not uncommon to find machines having positive suction and automatic delivery valves. The great difficulty with delivery valves of the automatic type is to avoid the severe banging or slamming to which they are liable.

Few classes of machinery are subjected to more severe stresses than steam-driven air compressors; and as these may, for the most part, be eliminated by a judicious valve setting, it will be convenient to consider the matter in the present article. The great shock with most compressors occurs on the dead centre when, under ordinary circumstances, the load on the piston-line is equal to the sum of the steam and air piston loads; for when the crank is in this position the full steam pressure is on the steam piston, due to lead of the steam valves, and also on the air piston, and as both these forces are acting in one direction the resultant force is the sum of the two components. To resist this great force most modern compressors are made extra strong in all parts between the crank shaft and the steam cylinder. The piston rod is larger in diameter at the crank end of the steam cylinder than between the steam and air cylinders, a state of things which appears to be absurd until the nature of the stresses is thoroughly appreciated. To avoid this shock it is only necessary to dispense with lead and set the steam valves so that the port is not opened until the crank has passed the dead centre.

Besides the types already mentioned the hinge valve is sometimes employed. This valve, however, is liable to severe banging unless the lift is small and there is special gear provided to prevent dancing on the face. For low pressures slide valves are

sometimes used, but it is obvious that this type is not well adapted for giving small clearances. Blowing engines, which are a type of low-pressure air compressors, have sometimes been fitted with rubber valves, and sometimes with valves of leather; but such designs are necessarily limited to low pressures, both on account of their being unable to resist high temperatures as well as high pressures.—*Engineering Review.*



THE SARGENT METER WITH THE BOTTOM BONNET REMOVED.

The Sargent Steam, Compressed Air and Gas Meter.

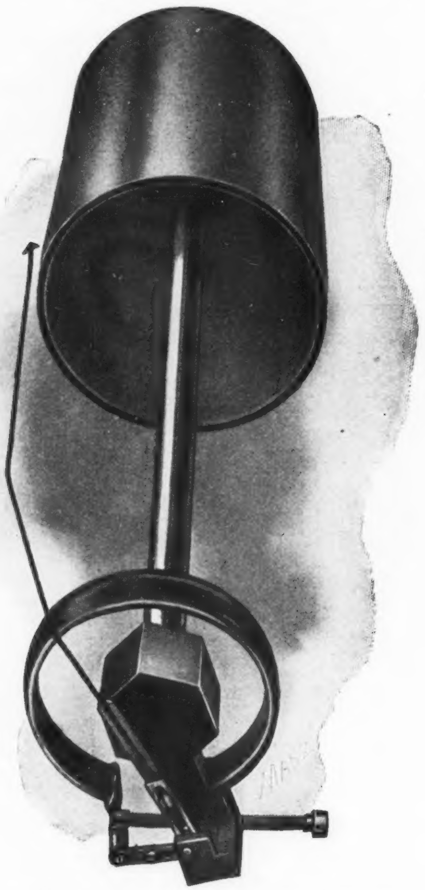
The demand for a practical device which will measure or indicate to the observer the amount of steam, air, gas or any vapor flowing through a pipe, has led to the manufacture of the Sargent meter, an instrument that will indicate the amount passing through it irrespective of the fluctuations of the pressure.

To determine the amount of the steam, air or gas used by the industrial plants a test is often necessary. And while this can be done in some plants by the installation of expensive and complicated apparatus, in other plants an accurate test even under these conditions is impossible. The Sargent meter indicates the amount that is passing through the pipe at any pressure

within the limits of its calibration, no matter what the variations may be, and as the meter is calibrated by running it through an actual test the indications in service must coincide with the indications found in calibrating the meter.

The illustrations show the improved Sargent meter. It is connected up in a pipe line or by-pass, which allows all the air, gas or steam to be measured to pass through, and this amount is indicated by the needle on the dial. The meters are made in "rights" and "lefts," as the purchaser may desire.

In the sectional view of the meter you will see that the air, steam or gas enters the meter at the left, passes up through the valve seat and out at the ports at the top, raising the valve "I" as the volume increases. The greater the volume at the same pressure, the higher the valve is raised, but when a constant pressure is passing through, the valve opening would be twice as wide for 50 pounds pressure as it would if the same amount was passing through at 100 pounds pressure, from which you will see that the graduating lines go down as the pressure increases.

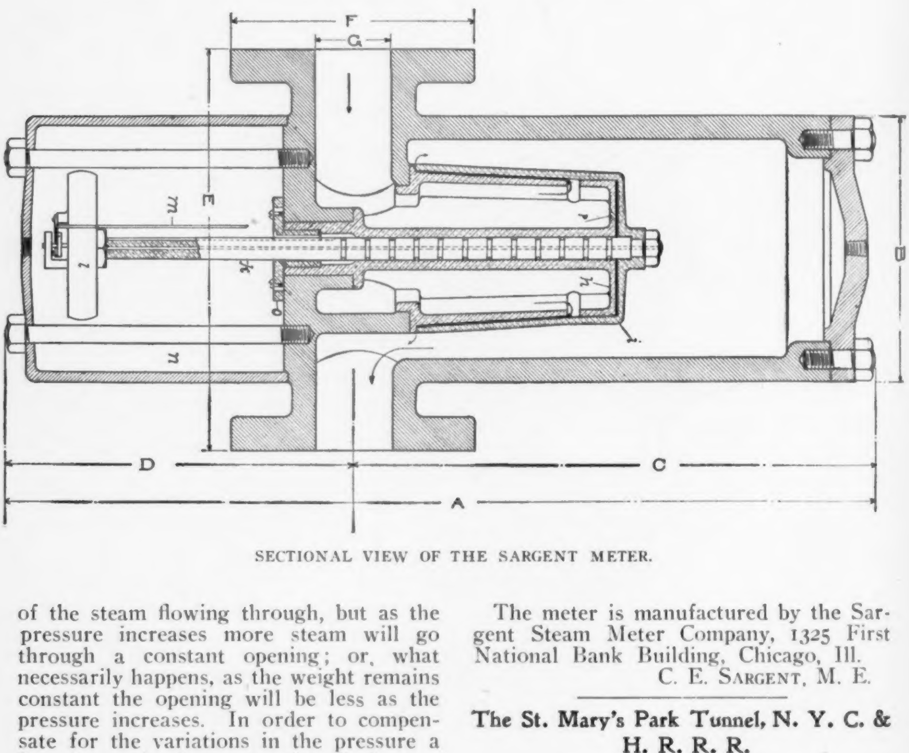


THE VALVE STEM AND SPRING, THE ONLY MOVING PARTS IN THE SARGENT METER.

As the valve stem is open to the atmosphere, the pressure on the discharge side of the meter tends to close the valve. As the area of the valve stem is about 2 per cent. of the valve area it follows that there will be a 2 per cent. difference in the pressure between the outside and the inside of the valve, and that to maintain the difference the valve will assume new positions, depending upon the volume and pressure of the gas flowing through. If the pressure were constant the rise of the valve would be in proportion to the weight of the steam flowing through, but as the pressure increases more steam will go through a constant opening; or, what necessarily happens, as the weight remains constant the opening will be less as the pressure increases. In order to compensate for the variations in the pressure a Bourdon spring is connected to the bottom of the valve stem, which moves the needle transversely as the pressure varies. Therefore the pointer necessarily has a different position for the different pressures and also a different position for the different quantities passing through.

A meter that is calibrated carefully must be correct when used in practice. With a very little attention the meter should be kept in the very best of order, as there is but one moving part used in its construction.

This meter was manufactured for measuring steam, and has stood the most rigid tests given it by the leading steam users of the United States, but finding that there was a demand for a meter of this kind for compressed air and natural gas, it was calibrated for these conditions and was found to be perfectly reliable. It is also used for getting the capacity of natural gas wells.



SECTIONAL VIEW OF THE SARGENT METER.

The meter is manufactured by the Sargent Steam Meter Company, 1325 First National Bank Building, Chicago, Ill.

C. E. SARGENT, M. E.

The St. Mary's Park Tunnel, N. Y. C. & H. R. R. R.

As a part of the depression and rectification work on the Port Morris Branch of the Harlem Division of the New York Central & Hudson River Railroad, a short tunnel is being driven under St. Mary's Park. The park is near One Hundred and Forty-ninth street and St. Ann's avenue, in the Borough of The Bronx, New York City.

The two most interesting features of this tunnel work are the location and loading of drill holes, and the loading of muck with a steam shovel operated by compressed air. Steam shovels have been used before in tunnel work, but never, so far as we know, within the limits of Greater New York. The gneiss and mica-schist of New York break out in much larger chunks than the shales and sandstones of Pennsylvania, where steam shovels have been used in tunneling, and for this reason the spacing of the drill holes and the charging of the holes on the St. Mary's Park tunnel work will be of particular interest to contractors and engineers as

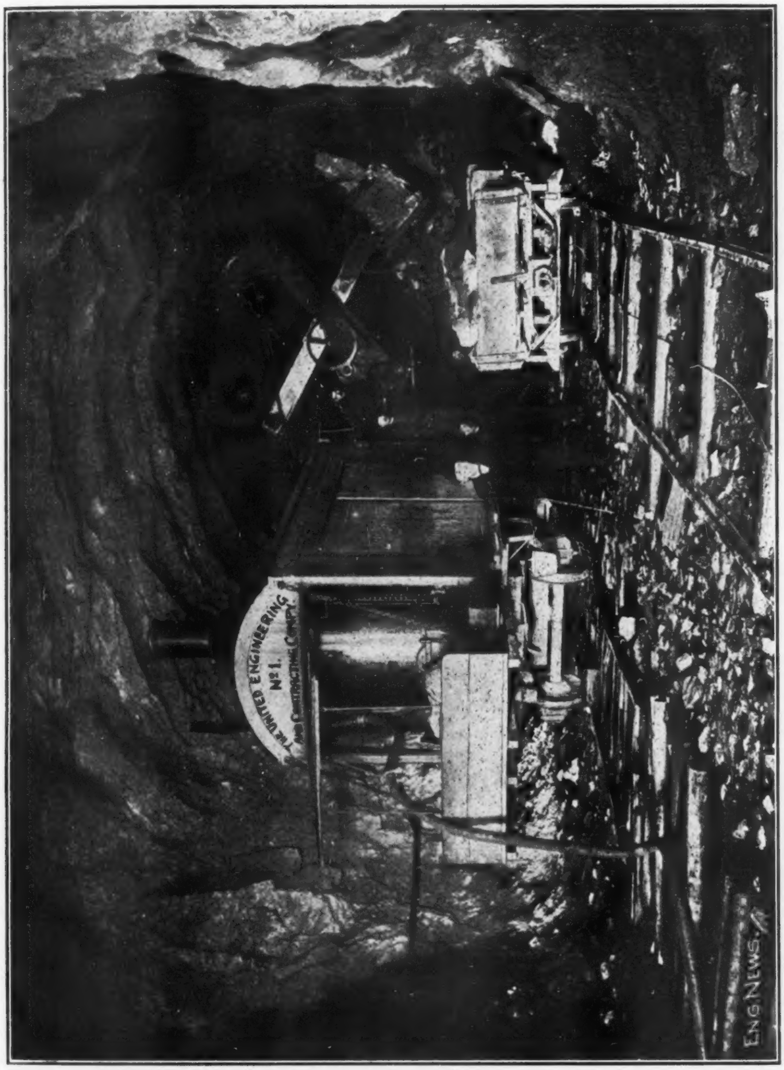


FIG. 1—STEAM SHOVEL AT WORK IN ST. MARY'S PARK TUNNEL, N. Y. C. & H. R. R.

furnishing a precedent for similar work in tough rock.

The top heading was first driven from portal to portal, its dimensions being 8 by 12 feet. Both dynamite and joveite were used in the heading blasting, the dynamite being 60 per cent. and the joveite of an equivalent grade. There was no material difference in the work done by the two kinds of explosives, pound for pound, and the average amount used was 6 pounds per cubic yard of rock. The heading averaged 4 cubic yards per linear foot.

The bench is being taken out in two lifts, the upper lift or bench being kept just in advance of the lower bench. Two rows of holes are drilled in each bench, charged and fired in order. The resulting breaking up of the rock is excellent; the writer has never seen a better example of heavy blasting in a tunnel. The huge muck heap is attacked by a steam shovel, Marion Model 20, Figure 1, having a yard dipper. Before blasting, the shovel is hauled back about 100 feet by a line from the hoisting engine which handles the muck cars. These cars are each of 5 cubic yard capacity, and average about 2¾ cubic yards of solid rock per load. They are hauled out in trains of two by a hoisting engine, located in the approach cut, and up an inclined track supported on blocking and trestle, having a sufficient rise to carry the empty cars back by gravity. As soon as the loaded train passes out of the tunnel, the empty train runs in. The muck is lifted in skips by a derrick located on the bank above the approach cut, and dumped either into cars or into a dump heap. This dump heap is used as a stock pile for the crushing and concrete-mixing plant, which will be described in a subsequent issue. The shovel is now working about 350 feet from the south portal of the tunnel, and is giving perfect satisfaction. The crew operating it consists of the two shovel men, four pit men and a pit boss.

The contractors for this work are The United Engineering and Contracting Company, Nos. 13 to 21 Park Row, New York City, of which company Mr. D. L. Hough, M. Am. Soc. C. E., is president. The superintendent of the tunnel and approach work is Mr. H. H. Marden, Jr., M. Am. Soc. C. E.—*Engineering News.*

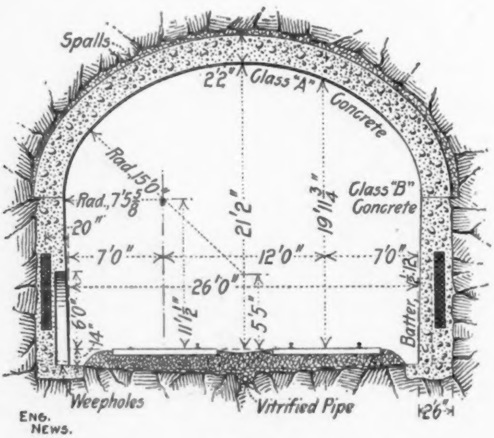


FIG. 2—ST. MARY'S PARK TUNNEL SECTION.

Cameron Pumps and their Construction.

The selection of pumping machinery is always a matter of importance, requiring a knowledge of the situation and the requirements, and a careful investigation of the claims of those presented for consideration. The type and size of pump depend upon the service and capacity required and the liquid to be pumped;

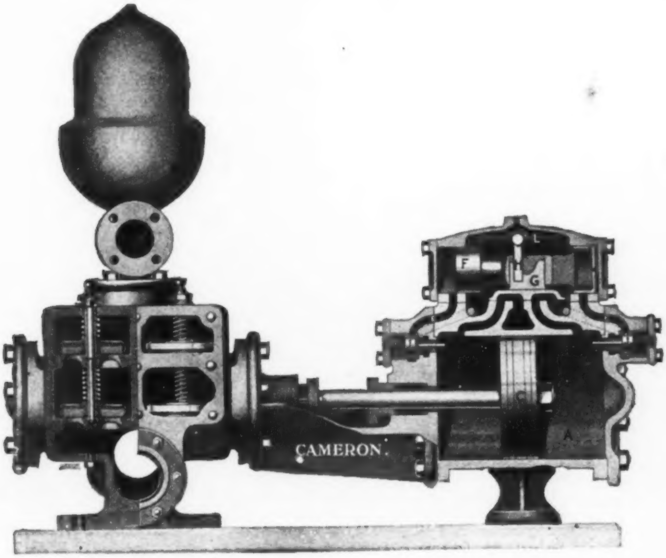
whether water, oil, tar, etc.; also whether clear or gritty, pure or impregnated with sulphur or other deleterious substances. Coupled with these must be considered the distance and elevation or the pressure to or against which the liquid is to be forced, also the steam or air pressure available at the pump.

It behooves the purchaser to be careful in his selection to investigate the claims and inquire of those who have already had experience with the make of pump offered. If the necessity of the situation precludes the possibility of research and investigation, then the user should be chary of new and untried experiments, or of those who are novices in manufacture, and should incline more to those whose product has stood the test of time and use. The question of first cost should not carry as much weight as cost of repairs and the expense and even danger of failure of operation and service.

All single direct-acting pumps make use of an auxiliary plunger to carry the main slide valve which gives steam to the main piston. By means of various devices steam pressure is made to drive this auxiliary plunger backward and forward.

The illustration shows a sectional view of a Cameron horizontal piston pump and of the regular type, which is adapted for general service, equally efficient with compressed air as with steam. The plunger is reversed by the means of two plain tappet valves, and the entire mechanism thus consists of four stout pieces only, all working in direct line with the main piston. Simple and without delicate parts, it is the only inside valve gear that is absolutely reliable.

A is the steam cylinder; *C*, the piston; *L*, the steam chest; *F*, the chest plunger, the right hand end of which is shown in section; *G*, the slide valve; *H*, a lever, by means of which the steam chest plunger *F* may be reversed by hand when expedient. *II* are reversing valves; *KK* are reversing valve chamber bonnets, and *EE* are exhaust ports leading from the ends of steam chest direct to the main exhaust and closed by reversing valves *II*.



In the operation of the steam end, *C*, the piston is driven by steam admitted under the slide valve, *G*, which, as it is shifted backward and forward, alternately connects opposite ends of the

cylinder *A* with live steam pipe and exhaust. This slide valve *G* is shifted by the auxiliary plunger *F*; *F* is hollow at the ends, which are filled with steam, and this issuing through a hole in each end, fills the spaces between it and the heads of the steam chest in which it works. Pressure being equal at each end, this plunger *F*, under ordinary conditions, is balanced and motionless; but when the main piston *C* has traveled far enough to strike and open the reverse valve *I*, the steam exhausts through the port *E* from behind that end of the plunger *F*, which immediately shifts accordingly and carries with it the slide valve *G*, thus reversing the pump. No matter how fast the piston may be traveling, it must instantly reverse on touching the valve *I*. In its movement the plunger *F* acts as a slide valve to close the port *E*, and is cushioned on the confined steam between the ports and steam-chest cover. The reverse valves *II* are closed as soon as the piston *C* leaves them by a constant pressure of steam behind them conveyed direct from the steam chest through the ports shown by the dotted line.

The cut also shows the Cameron valve chest and arrangement of valves. The right-hand side is shown in full, as it appears when the bonnet is removed, and the left-hand side in section. The advantage of this valve chest lies in its accessibility. By simply removing the bonnet or cover the whole interior, with every valve, is plainly visible, turned inside out, so to speak, and not a speck of anything lodged there can escape detection. The shelves or decks are bored out tapering, and the brass seats forced in. They can thus be readily taken out and renewed at any time. Each stem holds two valves, with their springs one above the other, so that by simply unscrewing one plug and pulling up the stem both are released. It will be noticed that the Cameron valve chest is placed close to the ground and beside the water piston, instead of above it, as in other makes. The valves are therefore just so much nearer the water, and the suction lift is reduced accordingly. All Cameron pumps have two suction openings, one on each side, and the discharge opening can be turned in any direction desired.

H. H. Kress.

Progress in Valves for Air and Gas Compressors.*

In reply to the query "why do not the builders of steam-driven blowing engines, instead of using air cylinders of seven-feet diameter and five-feet stroke, use cylinders of less diameter, and for a speed of, say, forty-two revolutions per minute substitute a speed of one hundred revolutions per minute?" I received from one of the most accomplished and competent engineers in the United States the following statement, which I give verbatim:

"It has been found almost impossible to get an air valve-gear which would work satisfactorily at speeds much above fifty revolutions per minute on low-pressure work where the air cylinders are very large, and where the valve area, particularly that of the inlet, must be a very large percentage of the piston area in order to prevent a suction loss in filling the cylinder."

Again, in conversation with another able engineer, the superintendent of a well-known compressor works, regarding the possibility of improving the piston packing of air compressors, I was met by the statement that, while pistons could doubtless be improved, the need for improvement in valves was more pronounced, and that, as yet, for all kinds and sizes of compressors, and for all uses, no all-around satisfactory valve has been produced.

The poppet valve is the type most used during a period of thirty years. At one time it was flat-seated. Then the conical seat prevailed. Now some manufacturers are going back to the flat seat. For some purposes a single slide valve for suction and discharge in a double-acting compressor has answered well, even with a maximum unbalanced pressure of 150 pounds per square inch between suction and discharge. A slide valve for the suction with a poppet valve for discharge is also used for some compressors. Mechanically operated inlet valves of the Corliss type for the suction, and poppet valves for discharge, are now quite extensively used. These changes have followed each other in the quest for the ideal compressor valve which, when it arrives, will meet the requirements for all compressors, of whatever size they may be or whatever may be their application in the industrial arts;

* By Leicester Allen in *The Engineering Magazine*.

and, as change always argues dissatisfaction, it seems that I am backed by authority of first-rate engineers, as well as the facts in the history of air compression, when I assert that a perfectly satisfactory type of valve for air compressors does not exist.

The term, "air compressor" applies in its broadest sense as perfectly to what is more generally termed a vacuum pump as it does to a compound compressor which, inducting air at a pressure of one atmosphere, effects a pressure of twenty-eight atmospheres; in fact, the ratio of compression in a pump producing a vacuum as low as one inch of mercury is about 30, or as great as in compressing air at 62° F. from one to 29.92 atmospheres. But while for a small laboratory vacuum pump a valve of oiled silk will answer well for the suction, the poppet valve of the large blowing engine with suction pressure of one atmosphere requires a ponderous casting. If two suction valves are used for these large air cylinders, even with a mean velocity of flow through the valve openings of 8,000 feet per minute, it can be readily computed that the combined suction area for the air cylinder of a blowing engine 7 feet in diameter and 5 feet stroke must be 3.88 square feet; the diameter of each valve, if opened to full area, would be 18⅞ inches, nearly. Its lift to give full area would be a little more than 4¾ inches. It is easily conceived that such a valve, cast integrally with guides and strengthening ribs, must have a weight which, for practical reasons, precludes its actuation by a spring, and seating with a blow; hence they are actuated mechanically by rock-levers. But, at the best, quick seating of such a valve is impracticable and the speed of the engine is thus limited. It is true, however, that in blowing engines where gas instead of steam is used, a speed of 90 revolutions has been reached by the use of mechanically actuated valves. Few mechanical engineers, not directly engaged in the manufacture of air compressors, have considered the wide range of conditions here outlined as existing between the small vacuum pump and the ponderous blowing engine; and, in view of all the requirements, it may be doubted whether a valve meeting them all satisfactorily will ever be forthcoming.

But though vacuum pumps are, strictly speaking, compressors in the most general sense of the word, they are not commonly so called; and they have a peculiarity in their action which practically puts them—and all compressors which, after compressing to a stated pressure, cease working—in a class by themselves. This peculiarity is that their ratio of compression, when the space to be exhausted contains air at atmospheric pressure, is zero at beginning, and constantly increases to the end of the operation. It is true that compressors taking air at atmospheric pressure and forcing it into a receiver until the latter is filled with air at a prescribed pressure, start with a zero compression ratio which increases till the stated pressure in the receiver is attained; but at this period the compressed air is taken from the receiver as fast as it is forced in, for driving air motors or for other useful purposes. If this be done uniformly, the ratio of compression thereafter remains constant. If the air be drawn from the receiver in irregular quantity, there will be greater or less approach to uniformity in the ratio of compression. It will increase or decrease according to the demand for the compressed air, but will not constantly increase as is the case with the vacuum pump. It is, doubtless, this variation in pressure ratio, more than any other cause, which has influenced the use of poppet valves for the discharge of air compressors, aside from their automatic action which requires no special mechanism to control their movement except a spring to insure their prompt closing. It is, doubtless, also the fact that, because this variation of pressure ratio does not exist in connection with the filling of the compressor, or the suction, the use of positively actuated suction valves, in place of poppet valves, has been evolved in modern practice.

In cold-air refrigerating machines which use compressed air, delivered by a compressor, in an air engine wherein the air is expanded for the production of cold and the work of the expansion assists a steam engine to drive the machine, as soon as the machine arrives at the point of normal working, the pressure ratio becomes constant. The ordinary slide valve with a cut-off slide on the back works satisfactorily on these machines, and has been in use for years without creating a desire for anything better. There is no question that such a valve can be practically applied to any compressor which

works under a constant pressure ratio. Of course, with this kind of valve the suction is effected through what is the exhaust port, and the compressed air is discharged through what are the induction ports in a steam engine, the course of the air during its passage being exactly the reverse of that of steam. The slide on the back of the main valve uncovers the valve port at the point of the piston stroke whereat the pressure of discharge is reached, instead of covering the valve ports at the point of cut-off, as in the steam engine. These valves work noiselessly, and as only one is required for a double-acting compressor, while, at the least, four poppet valves are required, and as they are far more durable and less liable to derangement in their action than poppet valves, their advantages for all pumps working under constant pressure ratio, if no counter disadvantage existed, would seem obvious.

Unfortunately, a disadvantage does exist, which, in the case of vacuum pumps designed to effect a very good vacuum, is absolutely fatal, and which seems to be insurmountable. Such a valve cannot be applied to a double-acting pump without an amount of clearance between the face of the valve and the piston which prevents a sufficiently complete discharge of the compressed air. There arrives a time when the air filling this clearance compressed to atmospheric pressure, is enough, when it expands to the lower suction pressure, to completely fill the cylinder together with the clearance space, and suction ceases when this occurs. When this condition is established the limit of the vacuum is reached. But for compressors compressing air from a pressure of one atmosphere to a higher pressure, into a receiver from whence the contained air issues at a uniform rate (as is the case with the blowing engine) I can see no valid objection to this type of valve. In this and analogous cases the air is compressed to a stated pressure, and hence the ratio of compression is practically constant; therefore, the point at which the slide on the back of the compressor main valve should uncover the discharge port can be determined with exactness, and the valve gear set to positively attain such opening. In the case of air compression for supplying motors and lifts in a shop, an approximation to a uniform stated pressure can be gained by using a receiver of so large a capacity that a sudden demand for air supply will not materially lower the pressure before automatic regulation is effected.

The compound system of compression, besides other practical advantages, lessens the ill effects of clearance or waste spaces in the compressors by lessening the ratio of compression in each of the compressors used in the system. For this reason much better results are attained in vacuum pumps by compounding than are possible with a single-cylinder pump. But the fact is that only slight decrease of economical efficiency is caused by a moderate clearance in incondensable gas compression from atmospheric pressure to a higher pressure, and that, in pumps for such work, clearance is not the important defect it was once considered to be. A slight increase in the stroke or the diameter of the compressor cylinder, or of both diameter and stroke, will compensate for the diminution of capacity due to expansion of air remaining in the waste spaces after the discharge has ceased, and as this residual air gives back to the piston on the suction side nearly all the power required to compress it, an almost negligible loss of power is sustained.

Probably the poppet suction valve used in some of the single-acting vertical compressors works as satisfactorily as any valve that ever has been, or will be, devised for the purpose. This valve, when working, requires no spring for its closure, neither is gravity concerned in its action. It opens and closes by its *vis inertia* alone. It is, as well-known, placed in the piston instead of in the cylinder head or bonnet, and it is nicely balanced or poised on a coiled spring that supports its entire weight, allowing it, when at rest, to close down almost tight upon a conical seat to which it is nicely fitted by grinding. Now, if we could suppose a perfect vacuum to exist in the cylinder and the piston to have a velocity a little greater than that which the force of gravity would produce from rest in the time required for its movement, the valve would open and remain open during the downward stroke, and close and remain closed during the upward stroke. In actual work the space above the piston fills during the downward stroke, the gas being then transferred from the lower to the upper side of the piston. During this stroke inertia causes the valve to lag behind its seat, and, con-

sequently, to remain open independently of the pneumatic pressure. When the piston reverses its motion at the end of the downward stroke, the valve does not reverse its motion till it meets and closes upon its seat, this action taking place during about four degrees of crankpin revolution over the dead centre, and hence being well-nigh instantaneous. These single-acting compressors, allowing the use of the well-known safety-head, practically eliminate waste spaces on the compression side of the piston. I believe that, with the single-acting compressor having a perfectly acting piston and tight valves, as fine a vacuum can be produced as can be attained with any apparatus except the mercury air pump. The suction-valve seats accurately without noise, and is easily kept tight; but it can be used in single-acting compressors only, and while with such compressors poppet suction valves give less trouble than on the double-acting, the cylinders must be of nearly twice the diameter with equal stroke to reach the same capacity.

With regard to construction, we have two leading types of compressors—the single-acting and the double-acting reciprocating compressors—with, possibly, the promise of a third type—turbine compressors, which may be exploited sooner than expected. They are certainly within the range of mechanical possibility, reasoning from the success that has been reached with steam turbines. They will not be concerned with the compressor-valve question.

With regard to their action, we have three classes: compressors which work with a constant pressure ratio, those which work with a constantly increasing pressure ratio, and those which work with alternately increasing and diminishing pressure ratio.

The suction valves of all these compressors may be positively actuated by mechanism, and the discharge valves of the first and third classes may be positively actuated, provided the variable pressure ratio of the third class be reduced as much as possible by means already discussed. Both the first and third classes of compressors may be successfully operated by a single main slide-valve, with a cut-off slide if the pressure ratio varies little in the third class. The second class of compressors must have automatically acting discharge valves to avoid an excessive waste of motive power. The simplest form of automatic valve yet devised for air-compressor work is a poppet valve; but it has many defects. To afford full opening it requires too great lift, and if to avoid this defect a multiplicity of valves be used, defective closing cannot be positively attributed to any one of the valves without an examination of the entire set. Except in the case of the suction valve in the piston of the single-acting compressor, poppet valves are always more or less noisy and wear rapidly under continuous work. Obstructions, such as scale jarred from the interior of pipes, are liable to be trapped between their faces and their seats, and frequently injure the ground surfaces, necessitating regrinding. The springs, unless very carefully made and tempered, are apt to break, in which case a fragment of the broken spring may cause injury. In short, although the poppet valve may be the best automatic valve yet available, many an engineer has longed for something which would save the care required to insure its efficient operation.

The ideal valve is one that never leaves its seat. Of valves which in action remain constantly seated, we have the types of the common locomotive slide, the rotary, the piston valve, the oscillating rotary (of which the Corliss valve is the prime favorite) and a large variety of gears for positively actuating each of these types. The grid variety of slide valves and the piston valve can be made to give a large valve opening with less motion than others, and large suction-valve opening is essential to progress if smaller compressors with higher piston speeds are ever to take the place of the present machines. Proceeding from these types, there may yet be evolved valves reasonably satisfactory in meeting the requirements of each of the three classes of compressors; but the difference in these requirements seems to preclude the hope that any one kind of valve will answer for the entire category. But in our age of rapid progress who will venture to assume the *role* of a prophet?

The New Chicago Pneumatic Sand Sifter.

A new apparatus for sifting sand by air power has recently been brought out by the Chicago Pneumatic Tool Company, Chicago. As the accompanying engraving shows, the device consists of an ordi-

nary riddle suspended from a cast-iron frame work, which is bolted to a wall or post. The riddle is oscillated by a rod connecting with a piston in a valved cylinder, the whole mechanism of which is practically the same as that of a pneumatic hammer. When the air is turned on the riddle oscillates continuously until the air is again turned off. The machine has a positive stroke, and the manufacturer claims that it is capable of handling all the sand that two or three men can shovel into it.

SAND SIFTER BUILT BY THE CHICAGO PNEUMATIC TOOL COMPANY.

Often, and particularly in small foundries, it is desirable to use the same machine in various parts of the shop. For this reason it is made detachable from the base plate, which secures it to the column or wall, and may be quickly set up on another plate in some other part of the foundry, the air supply being taken by flexible hose from the nearest convenient outlet. The same apparatus is furnished with a tripod mounting for use where even more general portability is desired. —*The Iron Age.*

Temperatures in Air and Ammonia Compressor Cylinders.*

It is somewhat remarkable, as we review the field of engineering activity, to find so many indeterminate factors the values of which must be assumed in our investigations and in our actual work. When dealing with such factors, individual judgment is compelled to take the place of experimental data, with more or less chance for errors in final results. One of these indeterminate factors is the mean temperature of the interior of an air-compressor cylinder, taking in air at a stated temperature and pressure and discharging the air at a stated pressure. Does any one exist who could guarantee that from these data he can mathematically determine more than an approximation to the temperature of the air so discharged? Such an approximation may be all that is required for ordinary practice

*By Leicester Allen, in *The Engineering Magazine*.

in building and operating compressors, but it does not meet the requirements for the scientific investigation of some of the problems of air and ammonia compression.

Take, for example, a case wherein a very high pressure is desired to be attained, space and cost also imposing the condition that the compression be accomplished in as few stages as possible, without producing excessive temperatures in the cylinders. In dealing with such a problem, we have, of course, the well-established thermodynamic formulæ; but their use gives us theoretical results only, never attainable in practice. When we test by thermometers the temperature of compressed gases as they pass from the compressor cylinders, we find a wide discrepancy between the thermometrical readings and the theoretically calculated temperatures. We usually account for these discrepancies by attributing them to loss of heat by conduction through the walls of cylinders. We have never been able to find yet a perfectly non-conducting material of which to make, or with which to insulate, compressor cylinders, and so a notable fraction of the heat that would otherwise accumulate in the cylinder walls and the contained air escapes.

Now, with very exact thermometrical work, we can quantatively determine such escape by subtracting the heat contained in the discharged gas from that which it should theoretically contain as computed by the accepted thermodynamic formulæ; but having so found the transmitted heat, we still confront the question of the mean temperatures of the cylinder walls, cylinheads with their valves, and the piston with that part of the piston rod which alternately works within and without the cylinder space.

These temperatures have a fundamental importance in the consideration of the subjects of cylinder condensation in reciprocating steam engines, of superheating in ammonia compressors, and of such ratios of compression in air compressors as will be consistent with safety in their practical operation. One of the dangers in air compression which has not been fully recognized until within a quite recent period is the liability to explosion of air-compressor cylinders when the heat of compression is caused to exceed the flashing-point of the oil used for cylinder lubrication. Several more or less serious accidents of this nature have been recorded within a period of three or four years.

The interior temperatures of the metal of steam cylinders, pistons and heads have been experimentally determined for special cases, with a probable approximation to accuracy, but I know of no such experimental determination for air and ammonia-compressor cylinders. As related to the question of superheating in ammonia cylinders, these interior temperatures are important.

In the introduction to the admirable translation of M. Ledoux' "Ice-Making Machines" by Professors J. E. Denton, D. S. Jacobus and A. Riesenberger, page XXIX, Fifth Edition, Revised, speaking of ammonia compression ice-machines, it is said:

"In compression machines employing volatile vapors the principal cause of the loss of the theoretical result * * * is the heating of the ammonia, by the warm cylinder walls, during its entrance into the compressor, thereby expanding it, so that, to compress a pound of ammonia, a greater number of revolutions must be made by the compressing pumps than corresponds to the density of the ammonia gas as it issues from the brine tank."

The statement quoted is based upon experiments actually made in a most careful manner by Professor Denton, the results of which are tabulated on a folding sheet inserted between pages XVIII and XIX of the introduction. The volume of the condensed liquid ammonia, if there were neither loss by superheating between the brine tank and the pumps, nor in the pumps themselves, should be exactly proportional to the volume of gas drawn into the pump at each stroke. In Professor Denton's experiments the volume of the liquid was found to be much less per stroke than it would have been had the same cylinder volume of gas been inducted at the temperature of the suction. As nothing is known that can lessen the weight of a given volume of gas except expansion, and as heat is the only possible known force by which, under the conditions, a gas can be expanded, and as the weight of the gas entering the pump must be exactly equal to the weight of the liquid resulting from the condensation, and this weight is a constant exact function of the liquid volume at any stated temperature, the inference drawn by these writers that the principal loss of theoretical result is

due to superheating seems perfectly logical. Now, if the superheating be wholly caused by the contact of the gas with the previously heated cylinder walls, it follows that a system of compression which heats the cylinder less will superheat the gas less, such superheating being a function of the difference of the temperatures respectively of the interior cylinder surfaces and of the gas. (Such a system is the compound system of compression in two stages, with cooling after the first stage. The resulting temperature of a gas compressed adiabatically is a function of the ratio of compression.) If the compression be effected in two stages, with equal ratios of compression, each ratio will be the square root of the total ratio, and the application of the accepted thermodynamic formula for determining the final temperature of compression for any particular ratio of compression (the absolute temperature of the gas at the beginning of the compression being known) will show that the maximum final temperature will be much less in the two-stage than in the single-stage system.

Ammonia, as it enters the compressor in what is called dry compression, is either a saturated or a superheated vapor. Zeuner has supplied a formula for computation of temperatures of superheated vapors for any ratio of compression, and this is general for ammonia and for all condensible gases; and it is universally admitted that unless some liquid ammonia is passed into the compressor with the gas (wet compression), the gas at the beginning of the suction period will nearly always be slightly superheated. Assuming that in dry compression the gas is superheated slightly before it reaches the suction valves, in any case of dry compression the application of Zeuner's formula will theoretically determine the final temperature for any suction temperature and compression ratio. Air is, of course, in its normal condition, a mixture of superheated vapors.

Now, it is plain that the interior of the cylinder can never reach a higher temperature than that of the gas at the end of the compression. The material warmed by contact can never become warmer than that which warms it. This is a fundamental law of heat transmission. It is also plain that a surface alternately exposed at equal and short intervals, first to a medium hotter, and second to a medium colder than itself, must take, and substantially retain, some average temperature between the extremes. When the extremes are constant, it might plausibly be expected that the intermediate temperature would be the mean of the extremes.

The temperatures at different periods of the operation in Professor Denton's experiments are tabulated on page XXXIV of the introduction to the work already cited. In the suction pipe, just prior to entering the cylinder, the absolute temperature of the gas was 485 degrees F.; at the end of the suction it was computed to be probably 617.6 degrees F., the gas having been superheated 132.6 degrees; at the end of the compression it was 995 degrees F. The extremes of temperatures to which the interior surfaces of the cylinder were subjected are therefore 995 degrees and 485 degrees absolute, the mean of which is 740 degrees absolute. Assuming this to be the substantially average maximum temperature attained by the metal surfaces, we can reason as follows:

Since the metal can give off to the cooler inflowing gas during one revolution of the compressor crank no more heat than it receives during one revolution, while working uniformly, and while the gas gets warmer the metal gets cooler, the greatest possible superheating would be at the instant whereat the metal surfaces and the gas, the former by cooling and the latter by heating, mutually and simultaneously arrive at the same temperature. In neither the gas nor the metal is there any other known physical change during the superheating of the gas. If sufficient time for transmission of heat from the metal to the gas be allowed, the temperature will inevitably equalize in both. The weight of the metal cylinder with its piston and heads is enormously greater in comparison than the weight of the gas, but its specific heat is only about one-fourth that of the gas. Approximately, the cooling of any weight of cast iron through a given range of temperature would effect the heating of one-fourth of the same weight of ammonia through an equal range. The conclusion that only a very thin interior stratum of the iron is concerned in the cylinder superheating of air or ammonia, while entering a compressor cylinder, or in the cylinder condensation of steam during induction, has been generally accepted, and the preceding considerations render it probable that this

view will never be successfully disputed. But the metal heats throughout its entire mass, notwithstanding. The action of a steam jacket is to lessen cylinder condensation by transmission of heat from the exterior to the interior surface. So the action of the cold-water jacket almost universally used on air and ammonia compression cylinders tends to lessen the superheating, but the transfer of heat from surface to surface proceeds in an opposite direction.

The quantitative effect of the cold-water jacket in lessening the superheating has not been made the subject of such thorough investigation as has been devoted to steam jacketing, and few, if any, reliable data upon which to base conclusions are available. But, when cool water in considerable quantity is constantly passed through the compressor jackets and issues therefrom with a notable elevation of temperature, it is sure that the effect of this transfer of heat from the inner cylinder surface through the cylinder barrel and heads, and thence to the water, must diminish, in a greater or less degree, the temperature of the inner surface, and so decrease its power to superheat.

Professor Denton's experiments were made with a seventy-five ton ammonia dry-compression machine. No one who has read his paper describing these tests in the transactions of the American Society of Mechanical Engineers, will question the skill and care with which they were conducted, or will dispute his determination of the superheating, 132.6 degrees F., as a matter of fact. We have already seen that, to account for this wholly by transference of heat to the gas from the interior cylinder surface, this surface must have an average absolute maximum temperature of 740 degrees F. at the beginning of the suction. The inflowing gas had a well ascertained absolute temperature of 485 degrees F. Suppose an interior stratum of the metal at 740 degrees falls in temperature through the same range as the gas is superheated. Then, at the end of the suction and just prior to the beginning of compression, the absolute temperature of the superheated gas is substantially the same as that of the cast iron in contact with it, and such temperature will be the mean of 740 degrees and 485 degrees, or 612.5 degrees, which accords remarkably with the absolute temperature, 617.6 degrees, in Professor Denton's table.

But if a notable quantity of heat is constantly passing out from the inner stratum of metal into the jacket water, it is certain that the temperature of that stratum cannot be a mean of highest and lowest temperature of the gas in the pump, and that a part of the superheating must be accounted for by another cause, or causes. Such causes may be found in the friction of the pump-rod and piston, in the constant beating of the poppet valves on their seats, and the friction of the gas itself in passing through ports. We cannot accept these causes as sufficient in the aggregate to counterbalance the cooling by the water jacket. Professor Denton's determination was 713 British thermal units per minute removed by the jacket in the experiments under consideration; and the mechanical equivalent of the heat so removed was 554,714 foot-pounds per minute. The power of the steam engine was 2,395,800 foot-pounds per minute, and the total friction of the machine 18.6 per cent., or about 445,619 foot-pounds. It becomes evident from these figures that the heat removed by the jacket is in excess of that generated by the total friction of the machine, and therefore must be far in excess of the heat generated by the several frictions which can be possibly associated with the superheating of the gas during the suction period. The fact and the degree of the superheating are indisputable. The inference is irresistible that the principal cause is the transfer of heat from a thin interior stratum of the metal in contact with the gas; but the inference that other causes contribute to the observed results, seems equally unavoidable. It is impossible to conceive that, by simple contact, or any effect of radiation, the gas can ever be superheated to a temperature higher than a mean between the average temperature of the metal which imparts the heat and the minimum constant temperature of the gas during the inflow. It is impossible to conceive that, with a water jacket taking away 713 British thermal units per minute, the gas is superheated to even this degree. Of course a large percentage of the heat removed by the jacket is heat generated by the mechanical work of the compression, but during the suction period, the entire pump barrel being surrounded by cold water, we cannot be justified in supposing that the effect of jacket

cooling in reducing the temperature of the inner surface is so small as to be negligible.

The subject involves many experimental and theoretical difficulties. Some recent experiments (which, at present, it is not permissible to cite more specifically) made to determine the extent to which a two-stage compound compression with intermediate cooling would lessen superheating, as compared with that in a single-stage compression system, have demonstrated that there is less superheating in the two-stage system; but the results were not so conclusive as expected, and further experiments will be needed before any reliable data can be deduced.

Air Compressors and their Valve Gear.*

On approaching the subject of air compressors from the valve-gear standpoint, it is convenient to divide them into two classes, those having automatic valves and those in which the valves are positively controlled. Many compressors, it must be admitted, combine the two classes in their valve-gear, nevertheless the classification here adopted is a convenient one.

In comparing the merits of automatic and positive valve-compressors it is necessary to consider the conditions under which they operate before a true estimate of their relative advantages can be formed. Dealing first with the suction valves, those of the automatic class have the advantage that no extraneous gear such as eccentric rods and levers are necessary; but, on the other hand, the fluid resistance of an automatic compressor exceeds that of the positive type. Referring to Fig. 1, which shows diagrammatically a suction valve of the automatic class, it is evident that, before this valve can open, the pressure in the cylinder must be less than the pressure of the outside atmosphere. In the first place the spring offers some resistance to the opening of the valve; and further, the atmosphere acting on a smaller area than that part of the valve exposed to the cylinder must be in excess of the pressure in the cylinder before the valve can open. The effect of these conditions is to rarify the air drawn into the cylinder and thereby not only increase the resistance to the compressor but also to diminish its capacity. In most indicator diagrams from air compressors the result of a throttled suction is not clearly defined because the strength of the indicator spring is too great to show the rarefaction of the suction charge; but, if light spring cards were taken, the effect would be clearly seen in all automatic suction-valve compressors. Some years ago the writer indicated an air compressor at Wigan, and as

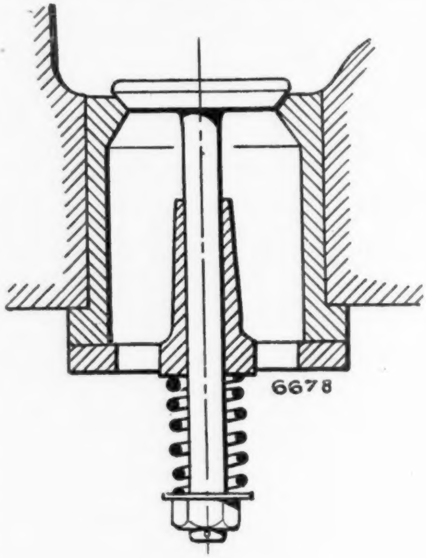


FIGURE 1.

the suction valves were suspected of throttling the inlet charge, a light spring card was taken, of which Fig. 2 is a reproduction. Here the throttling effect is clearly visible, and amounts to an average of $1\frac{1}{4}$ pounds per square inch throughout the suction stroke, thereby reducing the capacity of the compressor about $8\frac{1}{2}$ per cent. This is a serious loss of capacity, and is instructive in showing the effect of a slight imperfection in the valve gear. Positive action suction valves evade much of this loss, but their introduction leads to other considerations, which, if neglected, will more than nullify any gain arising from reduced suction resistance.

Take the case of an air compressor delivering into a receiver at a constant pressure, and giving an indicator diagram similar to Fig. 3. At the end of the de-

*By Charles Hurst, in the *Engineering Review* (Eng.).

livery stroke, and when the piston begins to recede, the air at receiver pressure left in the clearance space expands upon the retreating piston, as shown by the approximately hyperbolic curve at *A B* meeting the atmospheric line at the point *B*. Now the point *B* is where the suction-valve should open, and any departure from this point of opening entails loss. In a well-designed automatic valve-compressor the valve opens at the right instant, irrespective of any attention on the part of the attendant engineer, but an automatic valve-compressor requires an exact setting. The effect of improper opening is clearly illustrated in the diagrams Fig. 4. That to the right hand is taken from a compressor in which the suction-valve opens prematurely. The result of this faulty action is to allow the residual air in the clearance spaces to escape down the suction inlet, and the force which it might have exerted on the piston whilst expanding down to atmospheric pressure has been thrown away. The correct indicator diagram is shown by dotted lines, and the loss of power is represented by the area shaded. The left-hand figure shows the effect of late suction-opening. Here the residual air has expanded below atmospheric pressure, and an increased resistance has been thrown upon the piston to the extent of the shaded area. Now it is a comparatively easy matter to set the valves of a compressor when the machine is delivering air into a receiver with a constant pressure; but when that receiver pressure fluctuates considerably a positive suction-valve compressor must be working under uneconomical conditions, because for every pressure there is a particular instant at which the suction-valve must be opened to avoid loss, and it is obvious that, if correctly set for one certain pressure, the valves will be incorrectly adjusted for all others.

To illustrate this point clearly, take the concrete case of a compressor with a clearance volume of, say, 100 cubic inches, and delivering air at 75 pounds per square inch, by gauge. If the suction valve is correctly set, it will open when the air has expanded back to atmospheric pressure. This will occur when the piston has displaced about 500 cubic inches on the return stroke. Now suppose the receiver pressure reduced to 45 by gauge. Under these conditions the valve should open when the piston has displaced 300 cubic inches, and with the previous setting the compressor would be working at a disadvantage. From these considerations it would appear that, when the receiver pressure is constantly changing, a positive suction-valve compressor is at a disadvantage; but where the pressure is fairly constant, or where the changes are of sufficient duration to justify a re-setting of the valves, this type is to be preferred. In compound compressors the low-pressure or intake-cylinder may with advantage be fitted with mechanically moved valves for both suction and delivery, because in this cylinder a constant delivery-pressure to the intercooler is obtained in spite of fluctuations in pressure in the delivery main; and when the valves have once been set they require no further adjustment in the timing of their functions. It has been previously stated that the fluid resistance on the suction-stroke has a considerable effect in reducing the capacity of a machine, but in the second cyl-

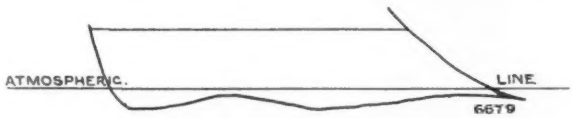


FIGURE 2.

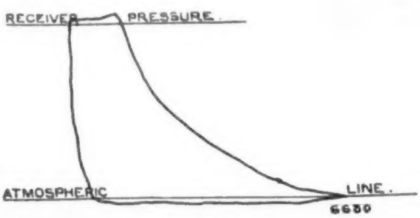


FIGURE 3.

inder it has little or no effect on the output.

If in entering the cylinder the air passes in thin streams through hot passages or ports, or past hot valves or seats, it will become rarefied, and thereby reduce the capacity of the compressor. The valve arrangements should therefore be designed to avoid this effect as much as possible. The passages leading to the suction port should be kept away from the heat of the cylinder, and should be as large and as direct as convenient.

Automatic delivery valves of air compressors are by far the most common type, and when well designed are quite satisfactory, and it is not uncommon to find machines having positive suction and automatic delivery valves. The great difficulty with delivery valves of the automatic type is to avoid the severe banging or slamming to which they are liable. No such severe action occurs with suction valves, because they open and close when the pressure in the cylinder is at or near atmospheric pressure. The closing movement of a delivery valve is the severest; and any delay in closing, through sticking of the valve hinges or stems, throws a severe blow on the faces and destroys them. With the object of avoiding this, the Reidler valve has been introduced. Figs. 5 to 7 will render the action of the valves clear. It will be noted that both suction and delivery are of the ring type, and present a double opening for air passage. Each valve is provided with a dash-pot chamber *C*, which prevents vibration on opening. The valves are automatic in their opening, but the closing is assisted by tappets *T*, shown in Fig. 6. These tappets move the valves until the latter are about 1-16 of an inch from the face, when they are free to fall on their face automatically. Having only 1-16 of free movement in closing, no serious banging can occur, and at the same time a large lift can be given without the slightest fear of hammering the faces unduly. Both suction and delivery valves are closed exactly at the end of the stroke, and therefore the tappets can be mounted on one spindle and driven from one rod, which is usually actuated by an eccentric on the

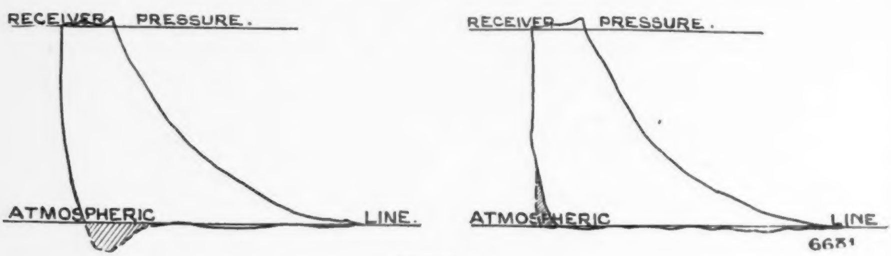


FIGURE 4.

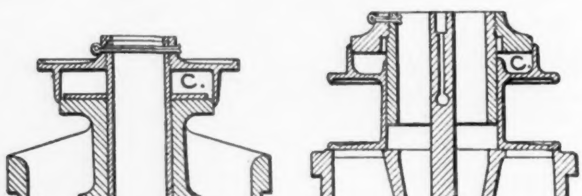


FIGURE 5.

crank-shaft in the case of power-driven compressors, and from a cam on the wrist-plate where the compressors are driven by Corliss engines.

A section of the cylinder end of a compressor having positive driven suction and automatic delivery valves is shown in Fig. 7. The inlet valve is of the Corliss type, and is actuated by a wrist-plate and levers in a manner similar to the exhaust gear of a Corliss steam engine. The eccentric is set in such a position that, when the piston has displaced a volume sufficient to allow the residual air in the clearance spaces to expand down to atmospheric pressure, the valve is just edge and edge with the port in the cylinder, whilst the closing of the valve is timed to occur exactly at the end of the suction stroke. The dwelling angle of the valve should be reduced to a minimum by the proper disposition of the wrist-plate, pins and valve levers, as is arranged in the exhaust-valve gear of most high-class Corliss steam engines. As to the delivery valves, it will be noted that they consist of a series of the mushroom spring-loaded type. Opposite each valve is a plug to give ready access to the valve and seat, which can both be withdrawn without disturbing the cover.

Small delivery valves of the spring-loaded automatic type, although convenient for access and free from the excessive banging of a large valve, have a disadvantage which is shown graphically in the indicator diagram Fig. 8. A perfect valve opens the instant the pressure in the cylinder reaches the receiver pressure, but the poppet valve is prevented from opening at the right instant because of its own weight, because of the spring resistance and by reason of the unequal areas respectively opposed to the cylinder and receiver pressure. The first two reasons are not of much account; but in order to appreciate the effect of unequal areas, take the case of a delivery valve having a seat 3 and 3½ inches diameter on the inside and outside of the seating respectively, and assume a receiver pressure of 100 pounds per square inch. The total pressure on the receiver side of the valve is 962 pounds, and before the valve can open the pressure in the cylinder must be—

$$\frac{962}{\frac{\pi \times 3^2}{4}} = 122 \text{ lbs. per sq. in.}$$

As soon as the valve opens there is an excess of the pressure on the delivery side, and the result is a violent vibration or dancing of the valve, which, in addition to injuring the valve springs, throws severe stresses on the crank pin, piston rod and bed plate of the compressor.

The above considerations show the importance of making the valve seating as narrow as is consistent with durability, to

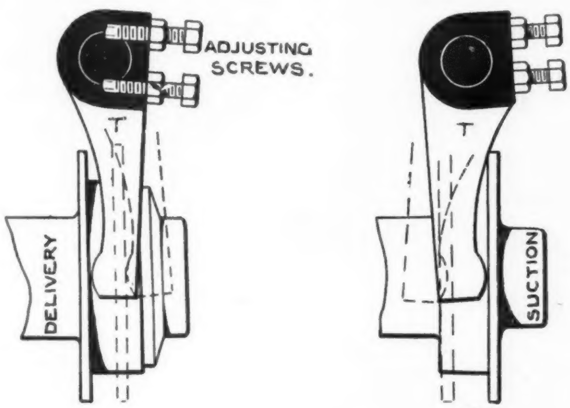


FIGURE 6.

avoid the result shown on the delivery line of the diagram.

Few classes of machinery are subjected to more severe stresses than steam-driven air compressors, and as these may, for the most part, be eliminated by a judicious valve setting, it will be convenient to consider the matter in the present article. The great shock with most compressors occurs on the dead centre, when, under ordinary conditions, the load on the piston line is equal to the sum of the steam and air piston loads; for when the crank is in this position the full steam pressure is on the steam piston, due to lead of the steam valves, and also on the air piston, and as both these forces are acting in one direction the resultant force is the sum of the two components. To resist this great force, most modern compressors are made extra strong in all parts between the crank shaft and the steam cylinder. The piston rod is larger in diameter at the crank end of the steam cylinder than between the steam and air cylinders, a state of things which appears to be absurd until the nature of the stresses is thoroughly appreciated. To avoid this shock it is only necessary to dispense with lead and set the steam valves so that the port is not opened until the crank has passed the dead centre.

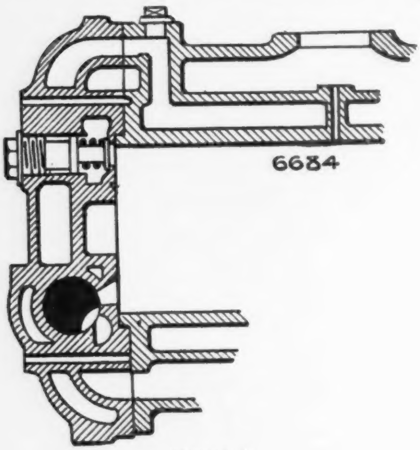


FIGURE 7.

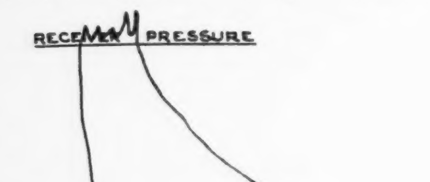


FIGURE 8.

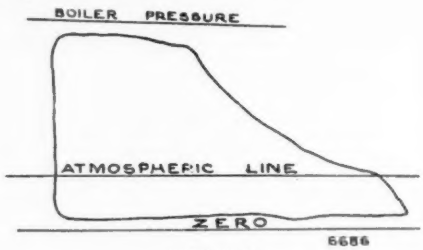


FIGURE 9.

If it were possible to make the steam-valve gear setting unalterable, most makers would send out their machines with negative lead, and the necessity for extra strength in the piston line and the framing would disappear; but as all valve gears are more or less at the mercy of the attendant engineer, whose ideas of valve setting may be anything but scientific, the makers are compelled to design their machine to withstand the worst possible case of valve setting. The accompanying diagrams from the steam cylinder of an automatic valve compressor will be interesting as showing the actual effect of improper setting when operating with the steam distribution portrayed by Fig. 9. This compressor gave much trouble. The pedestals

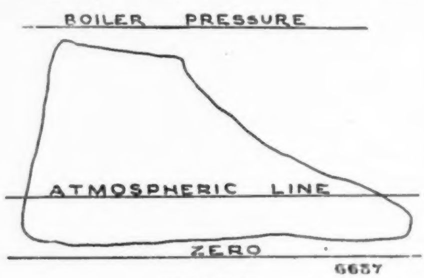


FIGURE 10.

were fractured after some three months' work, and when these had been replaced the piston rod gave out through the cotter hole in the crosshead, and the crank pier was slightly bent. The steam distribution was afterward altered, as shown in Fig. 10, and under these conditions the compressor has given no trouble.

The Ingersoll-Sergeant piston-inlet compressor is an interesting example in which a very free suction inlet is attained with an automatic valve, the inertia of which is useful in effecting prompt opening and closing. Referring to Fig. 11, which gives a section through the cylinder of one of these compressors, it will be noticed that the inlet valves consist of steel rings in the piston. They are restricted in the lift by a series of pins fitting into slots in the valves. The air enters by a tube at the back end of the cylinder and passes to the centre of the piston, and thence to the cylinder, through either of the valves. As the piston commences its stroke it has a tendency to leave the valve behind it, because of the latter's inertia, and would do so were the pins not provided. At the end of the stroke the reverse action takes place, when the valve has a tendency to outrun the piston, thus rendering closing extremely prompt. In consequence of the above-described action, the suction is extremely free, and the makers claim that a freer inlet is obtained than with any other type of compressor having automatic valves. The inaccessibility of the valves in the piston would be a serious objection if frequent examination and adjustment were necessary; but, in this case, there are no springs whatever, and the valve itself is a simple ring of high-quality mild steel, and practically indestructible. As to the delivery valves, it will be seen that they are of the usual poppet spring-closing type, with screwed-cap covers to render examination easy.

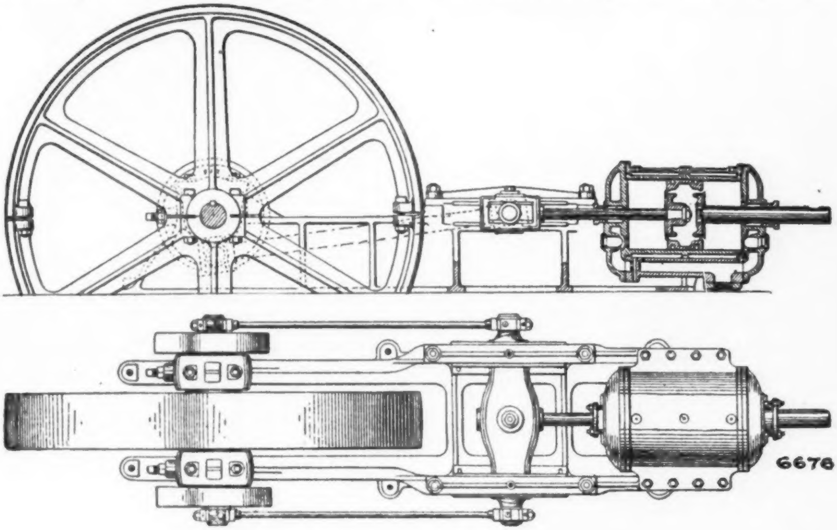


FIGURE 11.

Besides the types already mentioned, the hinge valve is sometimes employed. This valve, however, is liable to severe banging unless the lift is small, and there is special gear provided to prevent dancing on the face. For low pressures, slide valves are sometimes used, but it is obvious that this type is not well adapted for giving small clearances. Blowing engines, which are a type of low-pressure air compressors, have sometimes been fitted with rubber valves, and sometimes with valves of leather; but such designs are necessarily limited to low pressures, both on account of their being unable to resist high temperatures as well as high pressures.

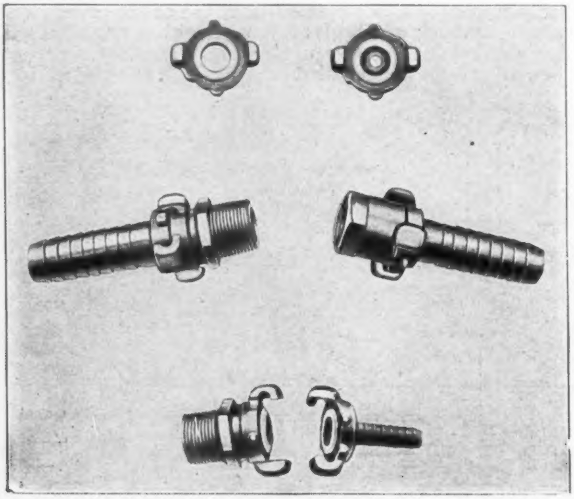
The Chicago Hose Coupler.

The Chicago hose coupler was designed to meet the demand for an universal coupler whereby a plant once standardized could economically thereafter be maintained standard without extra expense for specially constructed couplers to suit various sizes of hose used with pneumatic tools.

By reference to the illustration it will be observed the Chicago coupler has no male or female part at coupling end proper, but instead, each half has embodied therein both male and female features, whereby each and every half is exactly the same and will couple regardless of the style and size of the shank, rendering the same an universal coupler in every sense of the word. It will readily be seen that quarter-inch hose may be coupled with three-quarter inch hose, one-inch pipe, or to anything having one of the Chicago couplers attached to it.

The shanks are manufactured for pipe, male thread, pipe female thread, and hose in standard commercial sizes one-quarter inch up to one inch, which enables all couplings to be made without resorting to reducers or special shanks to meet the conditions presenting themselves where pneumatic tools are in use.

These couplers are manufactured by the Chicago Pneumatic Tool Company.



CHICAGO HOSE COUPLER.

An Improvised Air Compressor.*

It might be said that one would never know how high he could jump until he knew how deep a hole he would get in. An illustration of this fact is found in the following experience, which may perhaps be of use to others.

When a blast-furnace gets into a certain condition, which I will not attempt to describe, it is necessary to make holes through the walls to draw off the contents of the furnace at places where no provision was originally made, or where the holes originally provided have become stopped with an infusible mass of iron and cinder. After drilling into one of these masses, or

* By John J. Smith, in the *American Machinist*.

into the wall of the furnace itself, with an ordinary churn drill for a certain distance, the material encountered becomes sufficiently hot to be slightly pasty and to stick the drill, simultaneously drawing its temper. At the same time this pasty material is very much too hard to drive a bar through, and is absolutely infusible under any but the most intense heat. One of the favorite methods for making a hole into such a mass, where the electric arc is not at hand, is by means of an oil blow-pipe, which works on the same principle as the ordinary plumbers' lamp, increased in size about one hundred-fold, the interior pipe for carrying the kerosene being ¼-inch gas pipe, and the exterior one carrying the blast of air being ¾-inch gas pipe. Having a furnace in the lamentable condition mentioned above, a blow-pipe of this description was urgently needed, but no source of compressed air to supply the blast was at hand. The pressure of blast on the furnace was about 10 pounds, and this in desperation was tried for the blow-pipe, with fairly satisfactory results, but as a result of the operation of the blow-pipe, the cinder "notch" was burned open and also an additional tuyere, the furnace loosened up and the blast

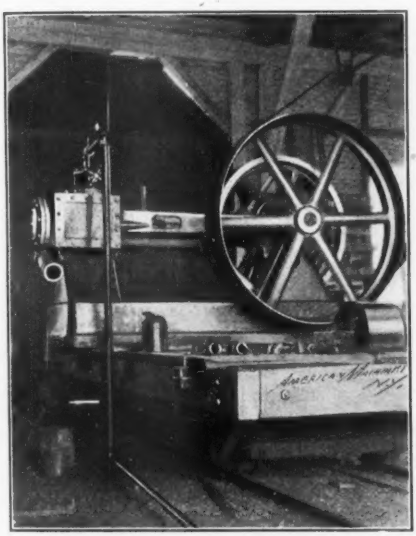


FIG. I—AN IMPROVED AIR COMPRESSOR.

pressure fell to about 5 pounds, so that it was no longer sufficient to operate the blow-pipes, though they were still urgently needed for further service. After much casting about for a possible source of compressed air, I remembered that we had on hand a 6½x10-inch single-valve Buckeye engine, and I said to the master mechanic that we would belt this up to the line-shaft in the carpenter shop (which happened to be the nearest), drive it backward with the shop engine and take compressed air from the steam or inlet side of the cylinder. He was skeptical of the proposition at first, but I reminded him that a steam card and air card were simply opposites of one another, and that the valve-gear diagram for an air compressor with positively-moved valves was simply that of a steam cylinder running in the opposite direction; and cited the familiar fact that a locomotive reversed when running down hill will pump air at a lively rate.

The practicability of the scheme being more or less settled from this point of view, I was lamenting that no larger engine was at hand, so that a greater volume of air could be obtained, when the master mechanic called my attention to the fact that we had just received a 10x12 inch straight-line, for an electric light plant then under way, which was still standing on the flat car on which it had been brought to the works. I had completely forgotten this as an available air compressor, but immediately had it sent for and placed in the carpenter shop on the track which ran parallel to the line shaft. The engine was then turned crosswise on the car, the belt from one of the wood-working machines run to it, the engine slewed back and forth until the pulleys were in line, as shown in Figure 1, and the shop engine started. In the meantime a line of 1½-inch pipe had been run to the furnace, some 250 feet away, and in a very short space of time we had 12 to 15 pounds pressure on the discharge pipe, which, of course, came from the throttle, and were operating our blow-pipe with great satisfaction. We subsequently made another blow-pipe and put it to work, doubling the speed of the engine at the same time. The pressure then went to 25 or 30 pounds, but the effect on the blow-pipes was very beneficial, and we continued to operate them, with the utmost satisfaction, whenever and wherever we desired until the trouble was over. When this happy

time arrived, as a matter of interest I put indicators on the engine while still in the original position, and obtained indicator cards from it. Not having two springs of the same strength, I used a 20-pound spring on one indicator, and a 30-pound spring on the other, which accounts for the difference in the height of the cards shown herewith in Figure 2. I also got a photograph of the entire layout in all its crudity, which is reproduced herewith. I supposed at the time that a better air card could be made by blocking the governor up, so as to give an earlier cut-off, but it was not the time to consider refinements of that character, and nothing of the kind was done.

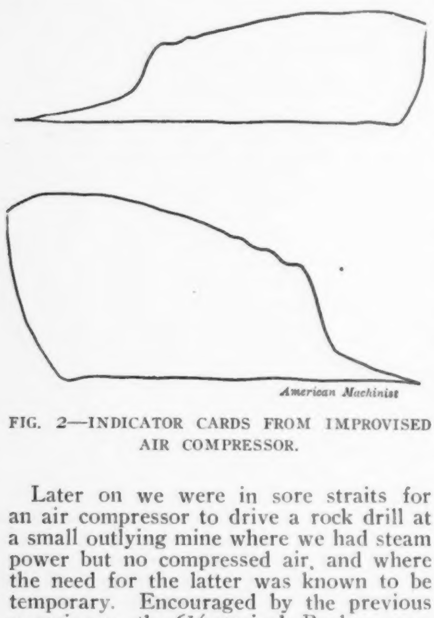


FIG. 2—INDICATOR CARDS FROM IMPROVISED AIR COMPRESSOR.

Later on we were in sore straits for an air compressor to drive a rock drill at a small outlying mine where we had steam power but no compressed air, and where the need for the latter was known to be temporary. Encouraged by the previous experiences, the 6½x10 inch Buckeye previously mentioned was tested with the idea of using it for the purpose, the rock drill being a very small one, and the quantity of air required only about 80 cubic feet per minute. It was at first impossible to maintain a pressure on the receiver of over 35 or 40 pounds, but a little investigation proved that the engine, which had done ten years of good service before being put aside for reasons not connected with its ability to do its work, had completely worn out its piston rings, and had also worn them very loose in the grooves. The grooves were trued up and new rings fitted, after which it was possible to produce a pressure of 75 or 80 pounds on the receiver.

The objection to an arrangement of this sort is that the clearance space is very great, and the re-expansion from it reduces the air introduced on the suction stroke, and the higher the pressure the worse this action; so much so that a very decided "puff" or back-kick from the suction can be felt at each stroke, when running against these high pressures.

When this engine was first sent to the outlying mine where it was to do duty as a compressor, it would not keep up the pressure, but the machinist sent to erect it observed this series of back-kicks and put a check valve on the in-take, which so far bettered matters that although there was only one check valve for both ends of the cylinder, the loss of air was so cut down that the compressor was able to maintain the pressure, and did so for a number of weeks, until the temporary task for which it was sent was accomplished.

The indicator cards from an engine run under such conditions are by no means ideal compressor cards, and the lack of economy is something calculated to horrify a college professor, but for a temporary expedient when a proper compressor is not to be had, an engine run backward with a plain slide valve set to "cut-off" about half-stroke will do fair duty, and will produce the desired result. It is not under any circumstances to be recommended as a compressor for permanent service, but may help someone out of sore trouble, as it did us in the cases described.

The Raising of Water by Compressed Air.*

Among the many mechanical expedients known to engineers at the present time, there are very few that have come into common use more rapidly than the application of compressed air to the raising of water from wells and borings. In this case, however, as in many others, we find that the practical application of a system has far preceded the appreciation

*Paper by Percy Griffith, M. Inst. C. E., read at the Engineering Conference of the Institution of Civil Engineers. Section VI.—Water Works, Sewerage, and Gas Works. June 19, 1903.

and understanding of the natural laws by which it is governed, with the inevitable result that, on the one hand, where success has been achieved, the advantages have been grossly exaggerated, and on the other, the failures have provoked unwarranted condemnation. No doubt the factor which is mainly responsible for this state of affairs is the simplicity of the apparatus involved. An air-compressor, driven by steam or electricity, with an air-pipe and a water-pipe having no moving parts, are the only requirements for the lifting of large quantities of water to very considerable heights under conditions which, in some instances, would be fatal to the ordinary form of pump.

At this point, however, the simplicity of the system, and especially of the laws under which it operates, absolutely ceases; and the more carefully it is investigated the more complex and indefinable become the problems presented by it. It is therefore very desirable that, instead of blindly experimenting with cases where failure may involve large sums of public money and the water-supply of communities (whether large or small), engineers should at once set themselves to a careful investigation, both of the natural laws which govern its operation and of the details of construction which are essential to its successful application.

Within the limits of the present paper it is impossible to deal with this subject as exhaustively as it deserves and the author is compelled to confine himself to a brief summary of those few points in respect of which experience hitherto has produced anything approaching to certain knowledge. Having collected data relative to a number of different installations, the author is bound to confess that, owing to the totally dissimilar forms in which the results have been recorded and the absence of any factors common to any two cases, the information he has accumulated, and the lessons to be learned therefrom, are of a somewhat negative character. Thus the proper proportion between the immersion of the air-nozzle, and the total "lift" of the water, and between the diameters of the air and water-pipes and the quantity of water to be lifted, the best form and the proper position of the air-nozzle, the relative cross-sectional areas of the air and water pipes, and whether the air-pipe should be inside or outside of the water-pipe, are all points upon which but little is definitely known, and upon which practice varies to a very tantalizing extent; in fact, it must be admitted that in almost every case these points are left entirely to experiment, and have never been settled with anything approaching finality.

Under these circumstances it is evident that, while no guarantee of success can be given in any particular instance, any attempt to estimate the duty or efficiency of any given plant is absolutely out of the question and, when this is done, it is obviously based entirely upon speculation and the chances of realization are very remote. The author would have liked to illustrate this point from his own experience and from the information he has collected, but as the scope of this paper renders this impossible, he must content himself with urging upon water engineers the necessity for careful and exhaustive experiments to determine once for all the conditions under which the best results are to be attained, and to define some common basis for the statement of those results, so that the actual cost of raising water by this system may be definitely arrived at.

Having thus pointed out the features of the system which are at present awaiting further explanation, the author will proceed to state briefly the broader aspects in which the suitability, or otherwise, of this very simple method of raising water is more obvious.

In considering the advantages of the system it must be emphatically stated at the outset that economy is not one of them, in spite of the claims made by some manufacturers. So far as it is possible to arrive at any comparison at all with the very meagre results at present available, the consumption of fuel with an air-lift plant will be at least three times as much as with an ordinary pump of an equal standard of general excellence and cost. Thus it may be taken as beyond dispute that, other conditions being equal, an air-lift plant cannot possibly compete with its older rival in respect of cost of fuel.

This being granted, there are, however, many circumstances under which

the use of compressed air for lifting water is more than justified, and where, in fact, it may prove the only solution of an otherwise insurmountable difficulty. The following cases may be accepted as typical:

1. For temporary use either in testing a well or boring, or in freeing a new boring of the floating dirt, sand or debris which always remains when boring operations are concluded; and

2. For permanent use where the water is derived from sand or gravel beds, and the sand cannot be entirely shut off from entering the boring.

In both these cases the absence of valves in contact with the water renders the air-lift system of great value; in fact, the author has met with several examples where the presence of sand in the water rendered the use of any ordinary form of pump impossible.

3. From a boring of any given diameter a much larger yield can be obtained by this system than with any other, and thus in many cases the use of an air-lift plant will avoid (or at least postpone) the necessity for sinking an additional boring (of course, at the expense of increased cost of fuel), and in others the hours of pumping can be materially reduced.

4. In cases where time is an important element, a simple air-lift plant of moderate capacity can be installed much more quickly than an ordinary pump, especially the part fixed in the boring. This is of the utmost importance when any prolonged interference with the boring would involve the interruption of the water supply of a town.

It must be observed, however, that this advantage does not apply to installations of a capacity exceeding 15,000 gallons per hour, where compressors of sufficient size are not obtainable from stock or on hire, or to cases where economy in working is essential, and the plant has to be elaborated for this purpose.

5. The initial cost of small air-lift plants, where economy of working is not essential, is decidedly less than that of an ordinary engine and pump, especially in respect of foundations and buildings.

For large installations, and where economical working is important, the author does not believe this is the case, although no figures can be given from actual practice.

6. Where the supply of water is derived from a number of borings or wells in the same neighborhood, a single air-compressing station will serve all the borings, and no plant or supervision need be provided at each boring.

It is, however, not quite clear whether the comparative economy of oil engines would not more than compensate for the expenses involved by the multiplication of power stations within certain limits.

In conclusion, attention may be called to a few general points which should always be borne in mind when an air-lift installation is in contemplation:

1. The proper depth or immersion of the air-nozzle, and the quantity of air required per unit of water lifted under different conditions of water-level, can only be ascertained by experiment in each case.

2. The air-lift system is only applicable to wells or borings in which the water stands under a considerable "artesian" head, *i. e.*, rises to a considerable height above the point at which it is "tapped."

3. By the air-lift the water-level can never be lowered much more than one-half the depth of the boring.

4. High lifts involve a great reduction in the efficiency of compressed-air plants and a corresponding increase in the proportionate cost of fuel; it is therefore never advisable to use this plant to lift water above ground-level; the provision of a separate force-pump for this purpose involves extra initial cost as well as increased working expenses.

5. The air-nozzle must be designed so that the rush of air does not impede the flow of water at the point of discharge.

6. It is obviously better to carry the air-pipe down the boring outside the water-pipe or rising-main in order to give increased area to the latter and to avoid the friction caused by the sockets on the air-pipe. In most cases the diameter of the boring will enable this to be done without difficulty.

7. The air-pipe must be large enough to avoid any unnecessary friction therein. The difficulty of this lies in the impossibility of previously determining the quantity of air required in any particular case.

8. Until some definite basis is arrived at for the calculation of the proportions

of the various parts of the plant, the system cannot be applied with any certainty of success or with any previous knowledge of the cost of fuel per unit of water lifted. The advantage of increasing the area of the water-pipe toward surface level (as advocated by one firm) has not yet been satisfactorily proved.

9. The economy in repair and maintenance, due to the absence of wear and tear in the plant fixed in the well or boring, is not, judging from the author's own experience, as important as it appears at first sight.

Notes.

"Air-Cooled Duntley Electric Drills," a special circular, No. 52, has been published by the Chicago Pneumatic Tool Co. It contains illustrations of the drill and suggestions as to its wide range of usefulness.

The annual meeting of the American Society of Refrigerating Engineers will be held in New York City on December 4 and 5, in the chambers of the American Society of Mechanical Engineers, No. 12 West Thirty-first street.

A portfolio of pictures of Corliss engines has just been issued by the C. & G. Cooper Company of Mt. Vernon, O. An idea of the general design of the Cooper Corliss engine is given, with the assistance of photographs of representative plants in operation.

A new bulletin, No. 101, has just been issued by the Sullivan Machinery Company, on "The Destruction of Henderson's Point, accomplished by novel methods," a lengthy account of which appeared in the August number of COMPRESSED AIR.

All hopes of opening the Simplon tunnel to traffic before the early months of next year have been abandoned. Falls of roof and cracks are continually reported and similar occurrences are taking place in the lesser gallery. The probable date of opening now mentioned is the beginning of April.

In a paper read by Dr. James Moir, reported in the July issue of the *Journal of the Chemical, Metallurgical and Mining Society of South Africa,* the question of the condition of the air in the Transvaal mines is considered under three heads: (1) Air from Compressors; (2) Ordinary Working Mine Air, and (3) Gases after Blasting with Nitro-glycerine Explosives.

Prof. L. H. Bailey, Director of the New York State School of Agriculture at Cornell, is writing several articles which are soon to appear in *The Century* on the subject of the young man and the farm. He will tell why he thinks the young man now leaves the farm, and he will show how the farm can be made more attractive and better worth the young man's while.

Engineers of refrigerating plants will find much to interest them in a book just issued by the D. Van Nostrand Company of New York. It is the work of Charles P. Paulding, M. E., and is entitled "The Transmission of Heat Through Cold Storage Insulation." Formulas, principles and data relating to insulation of every kind and the laws of experiments given by the French scientist, Péclet, as applicable to the art of refrigeration, are in convenient form.

A test of 31 drills at the Rose Deep Mine showed an average consumption of 81 cubic feet of free air per 3¼-inch drill per minute, including all leakage of pipes. The compressed air averaged 70 pounds per square inch. Each drill consumed the equivalent of 43 pounds of coal per hour; the compressor engine showed an average of 12.7 inches horse-power per drill and the mechanical efficiency of the engine was 86 per cent.—*South Africa.*

These were Ingersoll-Sergeant drills, bought prior to the year 1899.

William Barclay Parsons, member of the Isthmian Canal Commission of 1904-1905 and of the Board of Consulting Engineers, and a civil engineer of high repute, has prepared for the November *Century* a comprehensive account of the enterprise, discussing the most pressing problems of construction and their solution, the control of the American Government, work already accomplished, the claims of sea-levels and locks, Culebra

cut, recent changes in conditions, and many other matters of interest.

In the summer target practice of the United States Navy, which was carried on under battle conditions, each ship used on the large guns a device designed to prevent any explosion from the breech or flareback, such as caused loss of life aboard the "Missouri" on the Pensacola practice grounds. The device is merely the use of compressed air in the turrets, and the experts who noted its effect say that they believe that there never will be a flareback again. This use of compressed air was mentioned in COMPRESSED AIR when it was first suggested.

The mayor of Chicago has recently ordered that air pressure be used in the driving of all tunnels under that city. This resulted from the fact that in several instances depressions had appeared in the pavements above the tunnels and cracks were found in the walls of the neighboring buildings. It is a fact that contractors had already realized the importance of compressed air in this work, nearly all of the tunnels having been built under air pressure.

There are perhaps 40 to 50 miles of the tunnels in question, 7 feet by 9 feet, which are on the average of 40 feet under the surface. They are for hauling freight and are intended to connect with all buildings.

Primary methods of labor are probably more relied on in the mining industries of this country than in any other, so that it is not surprising to learn that out of a total coal output of 232,428,272 tons in Great Britain and Ireland for the year 1904, only 6,744,044 tons were mined by machines. In fully nine-tenths of the collieries of this country, the mines are worked wholly by hand, no use being made of mechanical cutters of any description. Nevertheless, the adoption of these machines appears to be rapidly extending. In 1902 only 483, mostly of the compressed air type, were working, but during the course of last year this number had almost doubled, 755 in all being in operation.—*Ex.* (English).

One of the practical uses of liquid air is the formation of a more perfect vacuum than is attainable by other means. The property possessed by charcoal of absorbing large quantities of gases is well known, and Professor Dewar has shown that this absorptive power increases largely at a low temperature. If a piece of charcoal is placed in a closed vessel, and cooled with liquid air, the vessel quickly becomes empty. The production of the vacuum is usually effected by first immersing the charcoal in liquid air, and then placing it in the vessel. In this way a vacuum suitable for the production of the X-rays, etc., can be obtained in a few minutes. By previous methods it was a matter of hours, or even days.—London (Eng.) *Globe.*

The prizes offered by *Engineering News* and the *Cement Age*, of New York, for the best papers on "The Manufacture of Concrete Blocks and Their Use in Building Construction" have just been awarded by the jury, which was composed of Messrs. Robert W. Lesley, past president of the American Cement Manufacturers' Association; Richard L. Humphrey, president of the Cement Users' Association, and Prof. Edgar Marburg, secretary of the American Society of Testing Materials.

The first prize of $250 was won by a paper by Mr. H. H. Rice, of Denver, Colorado, secretary of the American Hydraulic Stone Company. The second prize of $100 is given to a paper by Mr. William M. Torrance, C. E., of New York City, assistant engineer in charge of concrete-steel design for the Hudson Tunnel Companies.

The North Carolina Granite Corporation, of Mt. Airy, N. C., is now installing a Sullivan Corliss two-stage air compressor for driving the Sullivan drills and other compressed air appliances used at its quarries. This compressor has a capacity of 2,000 cubic feet of free air per minute, at 78 revolutions. The air cylinders are connected to a Sullivan Corliss cross compound, condensing steam end, especially designed and proportioned for this purpose. The air inlet valves are of the Corliss type, operated by independent eccentrics, and the discharge valves on both cylinders are of the automatic poppet type, moving in a direction parallel with the piston rod, with removable seats located in the cylinder heads. The devices for cooling the air during compression are unusually efficient. A similar machine is

installed at the works of the Southern States Portland Cement Co., at Rockmart, Ga., and has given very efficient service during the two years that it has been in operation.

The report of the Chief Inspector of Mines of India for 1904 states that at present coal-cutting machines are used at only two collieries in India. Nearly all the coal is won by the bord-and-pillar system (that is, by cutting the seams into pillars by driving galleries). The pillars are seldom extracted. The cheapness of Indian labor, compared with European and American, has probably prevented enterprise in the use of machines being shown in India. However, when the efficiency of the Indian miner is considered in comparison with that of the English miner, there would appear to be scope for the use of machines. The native miners have shown themselves capable of managing the machines; if a doubt remains as to a reduction in the cost per ton of machine-cut coal, there can be no question (as regards the great economy of time) in favor of the machines. With those now in use, a gallery could be driven at least twice as far in a given time as by hand.—London (Eng.) *Financial Times.*

The cleaning of the tunnels at the cessation of the steam traffic has been one of the problems raised by the electrification of the London Underground Railway.

To meet these requirements a machine has been designed by Mr. Ward, the master mechanic in charge of the Mill Hill sheds. This device consists of a 50-foot truck on which is mounted a double brush operated by compressed air. The brushes are mounted on a swivel, and can be elevated or depressed at will and turned from side to side by the slightest touch of the hand.

Power to operate these brushes is supplied by two air-compressors working at 200 pounds to the square inch. When the air is supplied the brushes revolve over the surface of the tunnel at a rate of 4,000 revolutions per minute. Several trials have been made with the cleaner with most satisfactory results.

The tunnels, after being thoroughly cleansed, will be whitewashed, considerably adding to the cheerfulness and comfort of the new mode of travel.

One of the newest appliances employed in the South Wales coal field for driving cross-measure drifts is a device for carrying rock drills, practically similar in construction to the carriage invented by the German engineer, Brandt, and used for driving the great Simplon tunnel. Resting on the carriage, and capable of being raised or lowered, is a level supporting a hydraulic bar, at one end of which two Eclipse drills are clamped, and at the other cast-iron balance-weights. The drills are clamped to the bar in such a way that they can be moved horizontally or vertically as desired toward any point in the face of the heading. The bar itself is hollow and contains a piston with a head which can be pressed outwards against the side of the heading with a force of 12½ tons, so as to fix the bar immovably. This is done by means of water under a pressure of 1,200 pounds per square inch, and the rate of drivage effected at the Elders Navigation Collieries by means of this carriage and the rock drills attached to it has been as high as 26 yards per week, whilst the average for two months' work has been 20 yards per week. With this carriage the drills can be taken to the face and fixed in position in 20 minutes ready for drilling the shot holes.

Another new contrivance has just been introduced at the same colliery for pushing full or empty trams into the cages without manual labor. It consists of a frame—one for each cage at the top and bottom of the pit, provided with two catches. When the tram is run toward the landing stage it is caught automatically between the catches and held in a position near the cage. When it is desired to push the tram and dislodge the one that has just descended or ascended the pit, the man in charge moves a lever, which sets in motion the piston of a compressed air cylinder attached to the frame, with the result that the tram held between the catches is pushed forcibly into the cage, where it dislodges the tram then inside, and occupies its place. The whole operation occupies only three or four seconds. It effects a great saving in time and in manual labor and increases appreciably the quantity of coal that can be raised from the shaft in any given time. The contrivance has just been patented, and as yet Elders' is the only colliery at which it is used.

At a recent meeting of the Society of Engineers, held at the Royal United Service Institution, Whitehall, London, a paper was read by Mr. Arthur H. Smith, A. M. Inst. M. and M. E., on "Machine Drills for Hard Rock," an abstract from which is as follows:

"The author first pointed out the immense importance of the subject to mining, civil and quarry engineers, setting forth the great services the rock drill had rendered in metalliferous mining and quarrying, and instancing some undertakings which would never have reached completion, and others which probably would not have been commenced, without the aid of machine boring. The history of rock drills was next outlined from Trevithick's machine to the steam percussion hammer introduced by Nasmyth, and its subsequent development for boring purposes by the Couch and Fowle patents, which included reciprocation and rotation, and were the direct forerunners of the present standard rock drill of a dozen first-class makers. The author then proceeded to describe hand drills, the first being driven by a crank handle, the blow being effected by the recoil of a compressed spring. The second is a device for grasping a bit, which is automatically lifted, rotated, and replaced after each stroke. Passing on to steam and compressed air actuated rock drills, attention was called to a compressed air hand drill, an evolution of the pneumatic chipping hammer. The author next proceeded to divide the present standard rock drill into two main classes—viz., the tappet valve type and the fluid moved valve type, mentioning *en passant,* the Darlington valveless types of 1873. After the working of the tappet and air-thrown valves had been explained, mention was made of a special tappet drill for 40-foot quarrying holes, also of a Corliss drill valve gear, and of the compound type of machine. Turning to electric drills, the two principals made use of in their construction were stated to be the conversion of the rotating motion of a motor into a reciprocating one by means of flexible live shaft and gearing, the actual striking being due to the recoil of a compressed spring, the second type deriving its reciprocating motion from the attractive power of solenoid coils upon a loose core or piston. The Brandt hydraulic drill was next noticed, the author describing it as a large hollow auger pushed forward with heavy pressure, and slowly rotated. He then referred to a novelty in the form of an internal-combustion motor-driven drill, operated by gasoline. Drill mountings and fittings were subsequently discussed, the author dealing with drill clamps, and incidentally with the question of 'nicking' and 'shearing' with special clamp arrangements. The author then observed that no paper on rock drills could be complete without a reference to miners' phthisis, considering the finding of the recent Royal Commission on that subject, which was appointed in consequence of the excessive mortality amongst returned Transvaal miners. The author stated that the disease was due to dust, which was effectually allayed by the Leyner and Brandt machines. He then proceeded to describe various systems of spraying and water injection attached to or incorporated with rock drills, and which had the same object in view. He then noticed the novel applications to which rock drills had been put, such as pile and bolt driving, steam hammer work, unstopping blast furnace tapping holes, and even to the flattening out of refrigerated hog bellies in America. The author concluded by reviewing the various types of rock drills and the different forms of power employed to actuate them. He emphasized the point that the business of a rock drill was not simply to cut rock, but to cut that rock as quickly as mechanically possible, and at the lowest cost, not only for actual power consumed, but also taking into consideration the relation of boring speed with its effect on capital and standing charges. For reasons which the author stated, his verdict was in favor of compressed air for actuating machine drills, and for mining work the standard compressed air rock drill arranged with an intermittent water-jet discharge at the drill point to cool the bit and to keep the cutting face clear of debris, thus insuring freedom from dust and quicker holing."

At the recent annual convention of the Wisconsin Granite and Marble Dealers' Association, held at Oshkosh, Wisconsin, some very interesting facts concerning the value of compressed air in the monument shop were brought out. A number of papers were read, among which was one by Mr. Fred K. Irvine, on "The Pneumatic Tool in the Retail Monument

Shop. Extracts from it are given, as follows:

"Only a few years ago there was a doubt in the minds of many monument men as to whether tools propelled by compressed air would ever be a pronounced success in the retail monument establishment where a small number of workmen were found adequate to take care of the business. Some of the concerns who were the first to put in compressors complained that it did not pay them. They froze out. They had leaks that could not be stopped, and the tools were claimed to be of imperfect construction; and with one excuse and another a great deal of dissatisfaction was expressed, and some of these concerns charged up considerable loss against their compressed air experiments, finally throwing out the machinery, and up to this day they are doing their work by hand, as it has been done from the time the Egyptians first carved the inscriptions upon their obelisks, which antedate all history.

"This may be termed the experimental stage of compressed air in the monumental establishment, for it was experiment, pure and simple, and the result of many experiments has been the steady and rapid improvement, both of the compressor plant and of the tool which does the work, so that to-day there are several absolutely perfect systems for compressing air to the necessary tension, and tools are to be had as perfect as human ingenuity, skill and experience can produce, so that the up-to-date monumental establishment finds compressed air and pneumatic tools practically as indispensable as the stone itself. When for any reason it is found necessary to close down the plant temporarily for repairs, or for any other reason, the workmen who have become familiar with the operation of pneumatic tools, in every instance, would prefer to lay off and lose the time than to return to the old method of mallet and chisel. In fact, the workmen soon learn to think that it is impossible to proceed without the air plant being in good working order.

"In the brief space of this little paper it will be impossible to take up technically the manner of using pneumatic tools, or the best method of undertaking the various kinds of surfacing plain letter, raised letter, or profusely carved jobs. These you are familiar with in practice every day, and could no doubt instruct me with volumes, where I could scarcely suggest a mere line, for such things depend more upon the skill of the sculptor and the natural gift of the worker, than anything else. But right here it will not be out of order to say that nature has so constructed some human beings that they are absolutely unqualified for the handling of delicate implements of any kind, although they may develop great skill with simpler tools. This is what we may call the personal equation, and many a workman who is held in high repute with his mallet and chisels has never succeeded in accomplishing anything which is either profitable or meritorious with the pneumatic tool. This personal equation has been very pertinent in many cases where failure was charged up directly to the fault of the tools.

"In the retail monument establishment the compressor plant is usually propelled by an electric motor, or a gas or steam engine. The only requirement in this regard is that good steady power of ample capacity be provided and the compressor be so connected with it that a steadily sustained speed is maintained at the driving pulley. The whole power plant, consisting of engine, compressor and air receiver, all properly connected, should be contained in one room, capable of maintaining a temperature above the freezing point. Concrete or brick foundations should be furnished for the machines producing the motive power and the compressor. and a good plan is to have the grindstones, power driven, in the same room, for here the tool sharpener will have to work a great deal of his time, and he will see to it that the temperature of the room is kept to a degree of safety and comfort.

"In all installations of power there is a well-worn phrase which you have all no doubt heard many times, but which can never be passed over without an underscore for emphasis, namely, 'Have Plenty of Power. When you think you have just enough, double the capacity of your power.' Now, this is true of the old steam engine and is equally true of every contrivance that has since been invented. Have plenty of reserve power to drive your compressor, and don't try to save a few dollars by buying a compressor which barely has the capacity to take care of your work. If you have twice as much compressed air capacity as you need at

the outset, be sure you will find additional uses for this great modern convenience than you have ever anticipated, and provide the capacity in the first place for additional tools, that you will be sure to put in, and other uses to which you will be applying compressed air.

"This matter of capacity cannot be emphasized too much, for many of the so-called breakdowns that appeared in the plants of former times were due largely to an attempt to get the compressor to give more power than it was ever designed to produce. Frequently you force the machinery salesman to take your order for a compressor which he knows is too small for your requirements, and your dissatisfaction almost invariably follows. A number of reliable machinery builders are making perfect air compressing installations, and are in a position to advise the proper capacity to take care of a given amount of work, and in most cases it is well to consider the suggestions of these experts, whose observation is usually very wide indeed.

"Have everything about your power room wiped up as neat as a pin; have all the oil cups filled each day with its proper kind of oil; go over the connections and hose joints carefully from time to time, and test for leaks at stated periods; in fact, exercise constantly a careful inspection of your air supply from the compressor to the connection at the tool, so as to keep it up to the highest state of efficiency. Air under pressure is very thin and will run through a very small opening, entailing waste and depreciation of the efficiency of the plant."

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U.S. PATENTS GRANTED SEPT., 1905.

Specially prepared for COMPRESSED AIR.

798,674. AIR-BLAST NOZZLE. Joseph Haas, San Francisco, Cal., assignor to Sanitary Devices Manufacturing Company, San Francisco, Cal., a Corporation. Filed Feb. 23, 1905. Serial No. 246,993.

798,919. PNEUMATIC BLAST DEVICE. George G. Nightingale, New York, N. Y., assignor to Leo Rosengarten, New York, N. Y. Filed Jan. 28, 1905. Serial No. 243,022.

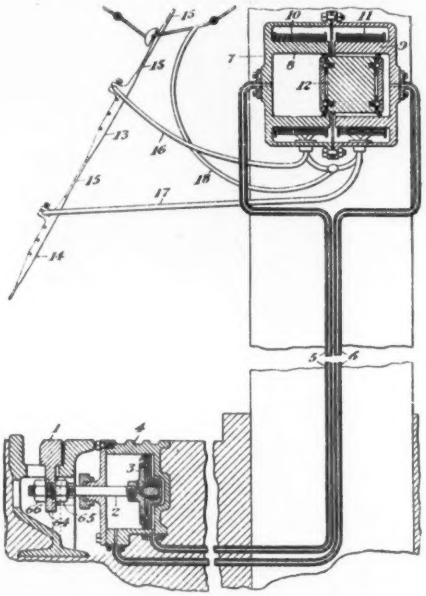
A pneumatic blast device the combination with a pair of pipes, of a union rotatably mounted on said pipes and having a spraying wall or partition therein, a nozzle-head and a rotary pipe connection between said nozzle-head and said union at a point in said union opposite said spraying wall or partition.

799,064. PNEUMATIC OR HYDRAULIC TRANSMISSION OF ELECTRIC POWER. Hans Kowsky, Hastings upon Hudson, N. Y. Filed Sept. 5, 1902. Serial No. 122,213.

A device for power transmission, the combination with the mechanism to be driven, of a piston, reciprocating in a cylinder, pipes extending from said cylinder and terminating in another cylinder, a piston reciprocating in the latter by the action of an electromagnet, or electromagnets, and means to energize said electromagnet or electromagnets alternately.

A device for power transmission, the combination with the mechanism to be driven, of a piston reciprocating in a cylinder, pipes extending from the latter and terminating in another cylinder, a piston in the latter fitting the mantle of the cylinder tightly and acting as the armature and part of the magnetic circuit of each of two electromagnets when energized, said electromagnets arranged with their axes in a straight line and their poles in opposition to each other,

the core of each of the electromagnets hollowed out and each surface of a disk-shaped armature provided with a central plunger-like protuberance to fit the hole of each of the cores, each electromagnet and each surface of the armature provided also with an outer annular jacket, so that the energization of one magnet will create poles of one order in the hollow magnet-core and the nearest armature-jacket, and poles of opposite



order in the magnet-jacket and the nearest armature-plunger, and each corresponding pair of these four poles is in constant close proximity to each other at all different positions of the armature and the long-range pull of the electromagnet is practically constant when the armature is close by or at a distant.

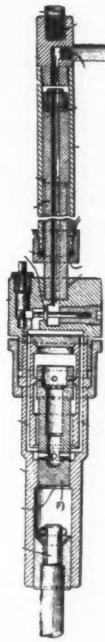
799,094. CLAMPING DEVICE FOR PNEUMATIC TIRES. Maximilian C. Schweinert, West Hoboken, N. J., and Henry P. Kraft, New York, N. Y. Filed Feb. 3, 1905. Serial No. 244,063.

799,164. PNEUMATIC TIRE. Thomas B. Jeffery, Kenosha, Wis. Filed Nov. 21, 1904. Serial No. 233,699.

799,186. AIR-BRAKE SYSTEM FOR STREET-RAILWAYS. Richard C. Quin, Toronto, Canada. Filed Jan. 24, 1905. Serial No. 242,541.

799,201. AIR-FEED FOR PNEUMATIC TOOLS. Frank L. Slocum, Concord, N. C. Filed Sept. 28, 1904. Serial No. 226,401.

799,145. FLUID-PRESSURE APPARATUS. John P. Coleman, Edgewood, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a Corporation of Pennsylvania. Filed Oct. 8, 1903. Renewed June 21, 1905. Serial No. 266,345.



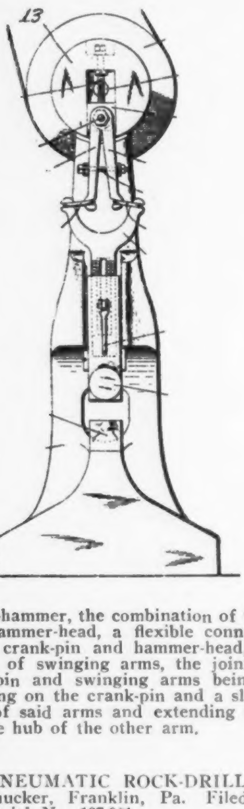
A device of the character specified, the combination with a fluid-pressure tool adapted for bodily rotation and provided with a supply-inlet at its outer end, of a hollow rod connected to said supply-inlet and extending outwardly in the axis of said tool, a piston on the end of said hollow rod, a cylinder in which said piston works, and an inlet to the outer end of said cylinder.

799,349. VACUUM FEED-CONTROLLING DEVICE FOR PRINTING-PRESSES. Alfred W. Massey, Chicago, Ill., assignor of one-half to W. J. Hartman, Chicago, Ill. Filed Nov. 18, 1904. Serial No. 233,275.

A printing-press, the combination of a platen-cylinder; a feed-platform for guiding a sheet of paper to said cylinder; a gripping device for securing the paper to said cylinder; guidetongues extending from said platform toward the cylinder; movable guide-fingers resting on said tongues to guide the front edge of a sheet of paper before the same is engaged by said gripping device, said guide-fingers being adapted to be withdrawn to permit the sheet to be engaged by said gripping device; said tongues being hollow and perforated near said fingers; and suction apparatus communicating with said hollow tongues and adapted to draw the sheet into contact with

said tongues and prevent the same from lifting when said fingers are withdrawn, substantially as described.

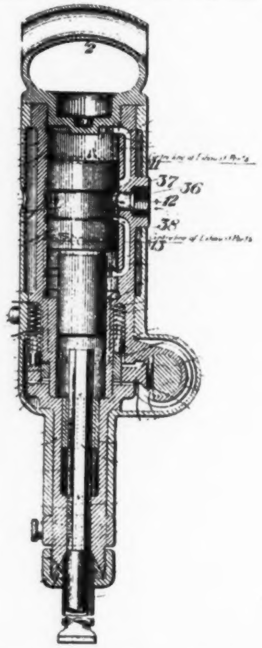
799,282. POWER-HAMMER. Hercule Vigneault, Worcester, Mass., assignor to Christopher C. Stone, George C. Stone, Walter A. Stone and Gerdon A. Brown, Clinton, Mass. Filed July 31, 1903. Serial No. 167,693.



A power-hammer, the combination of the crank-pin, the hammer-head, a flexible connection between the crank-pin and hammer-head, comprising a pair of swinging arms, the joint between the crank-pin and swinging arms being formed by a bushing on the crank-pin and a sleeve rigid with one of said arms and extending therefrom through the hub of the other arm.

799,406. PNEUMATIC ROCK-DRILL. Alfred P. Schmucker, Franklin, Pa. Filed Oct. 20, 1902. Serial No. 127,901.

A portable pneumatically-operable drill, the combination of a cylinder, a piston operable therein, a second cylinder, a piston operable therein, a port connecting one end of the first-mentioned cylinder with the corresponding end of said second-mentioned cylinder, a port connecting the opposite end of the first-mentioned cylinder with the corresponding opposite end of the second-mentioned cylinder, whereby pressure is admitted directly from the first-mentioned cylinder to the corresponding ends of said second-mentioned cylinder, the piston in said second-mentioned cylinder having a rack formed on one side thereof, a serrated ring having a segment of gear engaging said rack, an annulus, a drill-bit holder provided with ratchet-teeth adapted to engage teeth of said serrated ring, and the teeth



of said annulus, whereby the said drill-bit holder is rotated and backward movement thereof prevented, and a drill-bit seated in said holder.

799,575. PNEUMATIC CARPET-CLEANER. Edwin E. Overholt, Washington, D. C. Filed Sept. 1, 1904. Serial No. 223,011.

A pneumatic carpet-cleaner, the combination with a plate provided with a suitable aperture and adapted to rest upon the surface of a carpet to be cleaned, of a nozzle connected with said plate and arranged to project through said aperture to a point materially below the lower surface of said plate, and automatic means for resisting the relative rising of said nozzle.

799,808. SAND-BLAST APPARATUS. John E. Thompson, Pomeroy, Ohio. Filed Dec. 30, 1904. Serial No. 239.033.

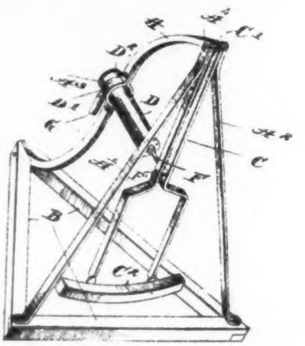
A sand-blast apparatus, the combination with a casing having an inlet-air pipe and an outlet-blast pipe, and a sand-supply opening in the top, of a sand-tank in the casing having a feed-valve into the outlet-pipe, and a rod, carrying a valve controlling said supply-opening, and extending into said feed-opening and movable to dislodge clogged sand therein.

799,880. DRILL FOR MINING PURPOSES. James Tonge, Jr., Westhoughton, near Bolton, England. Filed Nov. 6, 1903. Serial No. 180,033.

A drill comprising a tubular body provided with volute flanges, a plurality of said flanges

being slotted, and cutters provided with stems adapted to project through said slotted flanges, said tubular body being provided with holes or openings into which the ends of said stems are bent.

799,695. AIR-PUMP. Liberty Walkup, Rockford, Ill. Filed Sept. 4, 1903. Serial No. 171,950.



In mechanism of the class described, in combination, the legs A A^1 A^2, a leg, as A, having a transverse casing A^3 formed therein and all disposed in tripodal form and connected together, at their apex, by means of a pintle A^4, and, at their lower ends, by means of the triangular base B, a pendulum lever C suspended, by its upper end, from the pintle A^4, and provided, at its lower end, with a footrest C^2, an air-pump—comprising the cylinder D, cap D^2 and piston E—oscillatively mounted in the casing A^3, in the leg A, and a piston-rod F connecting the piston E, of the air-pump, with the pendulum lever C, substantially as and for the purpose specified.

800,003. AUTOMATIC CUT-OFF FOR PUMPS. Jeremiah Murphy, Leadville, Colo., assignor to Charles T. Carnahan, Leadville, Colo. Filed Mar. 27, 1905. Serial No. 252,335.

An automatic cut-off for motive fluid, comprising means operated by a jar of a pump or engine for throwing the cut-off into operation, thereby closing the supply of motive fluid.

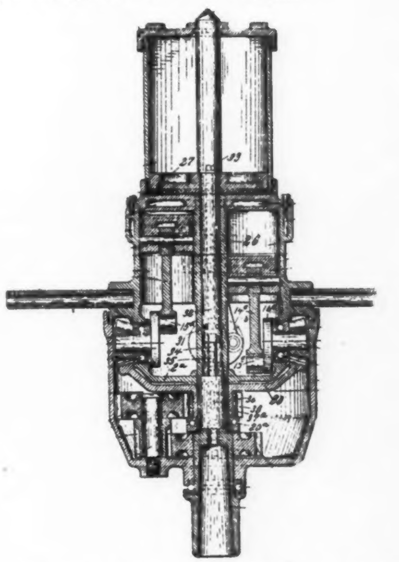
800,259. APPARATUS FOR SPRAYING LIQUIDS. George P. Barnes, Bromley, England. Filed Nov. 29, 1904. Serial No. 234,707.

800,275. PNEUMATIC DESPATCHING-TUBE SYSTEM. William H. Dinspel and Joseph J. Stoetzel, Chicago, Ill. Filed June 17, 1904. Serial No. 212,981.

800,292. PNEUMATIC CARPET-RENOVATOR. Carl Gunderson, Milwaukee, Wis. Filed Apr. 13, 1903. Serial No. 152,289.

A carpet-renovator, the combination of a dust-receiving chamber; a reciprocating brush adapted to loosen the dust in a carpet preparatory to entering said chamber; means for delivering the dust to said chamber; a pneumatic motor comprising a cylinder; a piston; means for communicating motion from the piston in said cylinder to said reciprocating brush and means for conducting air under pressure from the source of supply to said motor, substantially as set forth.

800,224. PNEUMATIC DRILL. Chester S. Leonard, Philadelphia, Pa., assignor of one-half to Ellsworth L. Ward, Philadelphia, Pa. Filed Feb. 23, 1905. Serial No. 246,928.

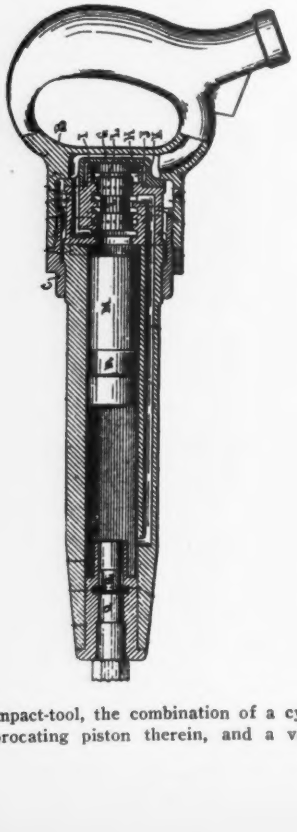


A device of the class described, the combination with the casing and driving-spindle, of a plurality of cylinders formed integrally within the said casing parallel with the driving-spindle and equidistant thereto; pistons in the said cylinders, crank-disks, pivoted connecting-rods connecting the disks and pistons, bevel-gears centered on said disks, a larger bevel-gear centered on the said spindle meshing with each of the said gears, cylindrical valve-chambers formed in the said casing in relation to their cylinders, slidable valves working therein, crank-disks connected to the said valves, and crank-operating bevel-gears arranged each between the said piston-gears and meshing with the said larger bevel-gear, all substantially as shown and described.

800,478. COAL-CUTTING MACHINE. Charles O. Palmer, Cleveland, Ohio. Filed Oct. 15, 1901. Serial No. 79,124.

The combination in a mining-machine, of a machine-frame, a worm-wheel journaled in said frame and carrying a cutter-arm with a revolving cutter thereon, a turret worm-shaft carrying a turret-worm and a worm-wheel 50, a longitudinal feed-shaft carrying a worm, and also the oppositely-revolving gears 51 and 53 respectively, having clutch-teeth, a sliding clutch-sleeve adapted to engage with either of said gears, a knock-off rod operating said sleeve, a hinged knock-off stop on the worm-wheel engaging the knock-off rod, means for revolving gears 51 and 52, means for revolving said cutter and means for holding said machine-frame in place.

800,329. PNEUMATIC TOOL. James A. Shepard, Montour Falls, N. Y., assignor to The General Pneumatic Tool Company, Montour Falls, N. Y. Filed Dec. 3, 1902. Serial No. 133,750.

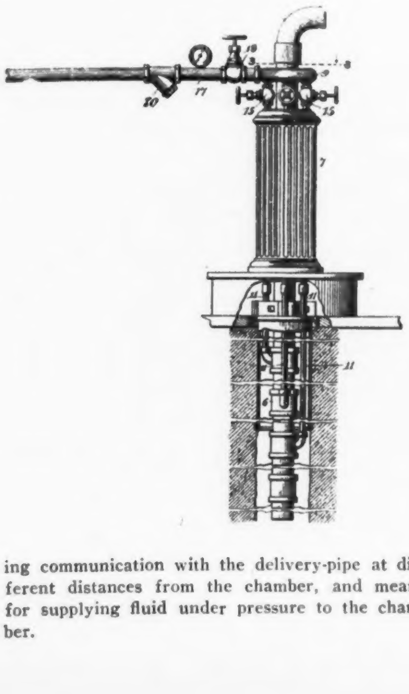


An impact-tool, the combination of a cylinder, a reciprocating piston therein, and a valve to control the movements of the piston, said valve having differential pressure areas, of which one of the smaller areas is constantly exposed to the intermittent pressure of the motive fluid in the cylinder acting on one side of the piston, the greater area being intermittently exposed to the pressure of the motive fluid acting upon the same side of the piston, and an intermediate area being intermittently exposed to the pressure of the motive fluid acting upon the opposite side of the piston.

800,358. BRAKING-REGULATOR. François J. Chapsal, Paris, and Alfred L. E. Saillot, La Garenne-Colombes, France. Filed May 9, 1905. Serial No. 259,616.

800,277. COMPRESSED-AIR WATER-ELEVATOR. Augustus W. Drake, Lattimer Mines, Pa. Filed Mar. 11, 1905. Serial No. 249,637.

A pump of the class described, the combination with a chamber for fluid under pressure, of a delivery-pipe passing directly and centrally through the chamber, said chamber thus surrounding the upper portion of the pipe, a plurality of supply-pipes leading from said chamber and having communication with the delivery-pipe at different distances from the chamber, and means for supplying fluid under pressure to the chamber.



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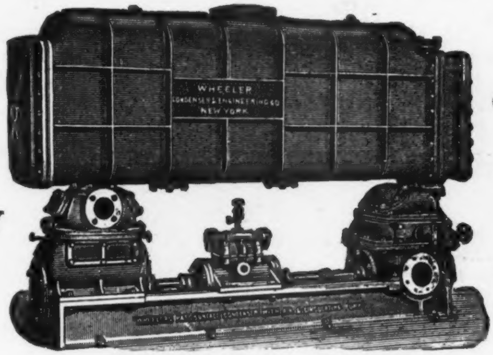

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